

APPENDIX A

CTDEP REMEDIATION STANDARD REGULATIONS

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A-1

CTDEP REMEDIATION STANDARD REGULATIONS

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concerning
REMEDIATION STANDARD

Section 1. The Regulations of Connecticut State Agencies are amended by adding a new section 22a-133k-1 as follows:

Section 22a-133k-1

(a) Definitions.

For the purposes of sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies, the following definitions apply:

- (1) "Analytical detection limit" means the minimum concentration of a substance that can be quantified consistently and reliably using methods approved by EPA and which concentration shall be (A) for a substance in ground water, equal to or less than the ground-water protection criterion for such substance determined (i) for a sample of ground water in a GA area using analytical methods specified in subpart C of 40 CFR part 141 or (ii) for a sample of ground water in a GB area using methods established pursuant to "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", SW-846, U.S. Environmental Protection Agency, Office of Solid Waste, Washington D.C. 20460; or (B) for a substance in soil, equal to or less than the residential direct exposure criteria or the applicable pollutant mobility criteria, whichever is lower using methods established pursuant to "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", SW-846, U.S. Environmental Protection Agency, Office of Solid Waste, Washington D.C. 20460.
- (2) "Aquifer protection area" means an aquifer protection area as defined in section 22a-354h of the General Statutes.
- (3) "Area of influence" means as "area of influence" as defined in section 22a-354b-1(a) of the Regulations of Connecticut State Agencies.
- (4) "Areal extent of a ground-water plume" means the surface area beneath which ground water has been or may be polluted by a release and in which ground water one or more substances from such release is or may be present at a concentration above the analytical detection limit.
- (5) "Background concentration for ground water" with respect to a particular release means the concentration of a substance in ground water (A) at the nearest location upgradient of and unaffected by the release; or (B) if such release occurred at or created a ground-water divide, at the nearest location representative of ground water quality unaffected by any release.
- (6) "Background concentration for soil" means the representative concentration of a substance in soil of similar texture and composition outside the subject release area and in the general geographic vicinity of such release area, but not within any other release area.
- (7) "Carcinogenic substance" means a substance defined as a "carcinogen" by federal or state agencies and for which a quantitative health risk extrapolation is available.
- (8) "CFR" means the Code of Federal Regulations.
- (9) "Commissioner" means the Commissioner of Environmental Protection or his designee.
- (10) "Dense non-aqueous phase liquid" means a non-aqueous phase liquid that has a density greater than water at 20 degrees Celsius.

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- (11) "Direct Exposure Criteria" means the concentrations identified in Appendix A to sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies or any alternative direct exposure criteria approved by the Commissioner pursuant to section 22a-133k-2(d) of the Regulations of Connecticut State Agencies.
- (12) "Downgradient" means in the direction of the maximum rate of decrease of hydraulic head.
- (13) "Downgradient area" with respect to a release of a substance means the area bounded by (A) the width of the release area of such substance perpendicular to the direction of ground-water flow, (B) two side boundary lines parallel to the downgradient direction of ground water flow extending from the two endpoints of said width to the downgradient parcel boundary, and (C) the downgradient parcel boundary extending between the two side boundary lines; excluding any portion of such downgradient area that is (i) affected by any other release of such substance or (ii) beneath an existing permanent structure.
- (14) "Environmental land use restriction" means an environmental land use restriction as defined in section 22a-133q-1 of the Regulations of Connecticut State Agencies.
- (15) "Environmentally isolated soil" means polluted soil which is: (A)(i) beneath an existing building or (ii) beneath another existing and permanent structure which the Commissioner has determined in writing would prevent the migration of pollutants; (B) not a continuing source of pollution; (C) not polluted with volatile organic substances or, if it is polluted with such substances, the concentration of such substances has been reduced in concentration to the maximum extent prudent; and (D) above the seasonal high water table.
- (16) "EPA" means the United States Environmental Protection Agency.
- (17) "Excess lifetime cancer risk" means the estimated probability that an individual's exposure to a substance could result in cancer.
- (18) "GA area" means an area where the ground-water classification is GA or GAA, respectively.
- (19) "GB area" means an area where the ground-water classification is GB.
- (20) "Ground water" means that portion of waters as defined in section 22a-423 of the General Statutes which portion is at or below the water table.
- (21) "Ground-water classification" means the ground-water classification goal or the ground-water classification, whichever is more stringent, established in the Water Quality Standards.
- (22) "Ground-water divide" means a line on the water table from which the water table slopes downward in both directions away from such line.
- (23) "Ground-water protection criteria" means the concentrations identified in Appendix C to sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies.
- (24) "Ground-water plume" means ground water which has been polluted by a release and in which ground water one or more substances from such release is present at a concentration above the analytical detection limit.
- (25) "Hazard index" means the calculation of the potential for non-cancer health effects as a result of exposure to one or more substances with the same or similar modes of toxic action or toxic endpoints.
- (26) "Hydraulic gradient" means the change in hydraulic head per unit distance.
- (27) "Hydraulic head" means the elevation to which water rises in a piezometer or a well.

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(28) "Inaccessible soil" means polluted soil which is: (A) more than four feet below the ground surface; (B) more than two feet below a paved surface comprised of a minimum of three inches of bituminous concrete or concrete, which two feet may include the depth of any material used as sub-base for the pavement; or (C)(i) beneath an existing building or (ii) beneath another existing permanent structure provided written notice that such structure will be used to prevent human contact with such soil has been provided to the Commissioner.

(29) "Industrial or commercial activity" means any activity related to the commercial production, distribution, manufacture or sale of goods or services, or any other activity which is not a residential activity as defined in subdivision (53) of this subsection.

(30) "Industrial/commercial direct exposure criteria" means the concentrations identified as industrial/commercial direct exposure criteria in Appendix A to sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies.

(31) "Industrial/commercial volatilization criteria" means the concentrations identified as industrial/commercial volatilization criteria in Appendices E and F to sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies.

(32) "Intermittent watercourse" means "intermittent watercourse" as defined in section 22a-38 of the General Statutes.

(33) "Light non-aqueous phase liquid" means a non-aqueous phase liquid that has a density equal to or less than water at 20 degrees Celsius.

(34) "Matrix interference effect" means the inability to measure the concentration of a substance in a sample at the analytical detection limit due to chemical interferences within the sample which interferences cannot be compensated for using methods approved by EPA.

(35) "Natural attenuation" means a decrease in concentration of a substance in ground water through operation of natural physical or chemical processes, including but not limited to adsorption, absorption, dilution, phase transfer, oxidation, organic complexation, biodegradation, dispersion and diffusion.

(36) "Non-aqueous phase liquid" means a liquid that is not dissolved in water.

(37) "Organooleptic" means the capability to produce a detectable sensory stimulus such as odor or taste.

(38) "Parcel" means a piece, tract or lot of land, together with the buildings and other improvements situated thereon, a legal description of which piece, parcel, tract or lot is contained in a deed or other instrument of conveyance.

(39) "PCB" means polychlorinated biphenyls.

(40) "PPB" means parts per billion.

(41) "PPM" means parts per million.

(42) "Person" means person as defined in section 22a-2(c) of the General Statutes.

(43) "Pollutant mobility criteria" means the concentrations identified in Appendix B to sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies or any alternative pollutant mobility criteria approved by the Commissioner pursuant to subsection 22a-133k-2(d) of the Regulations of Connecticut State Agencies.

(44) "Polluted fill" means soil or sediment which contained polluting substances at the time such soil or sediment was deposited as fill material.

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(45) "Polluted soil" means soil affected by a release of a substance at a concentration above the analytical detection limit for such substance.

(46) "Pollution" means pollution as defined in section 22a-423 of the General Statutes.

(47) "Potable water" means potable water as defined in section 22a-423 of the General Statutes.

(48) "Potential public water supply resource" means (A) any "potential well field" as defined in section 22a-354a of the General Statutes, or (B) any area identified by the Commissioner pursuant to section 22a-354c(b) of the General Statutes.

(49) "Prudent" means reasonable, after taking into consideration cost, in light of the social and environmental benefits.

(50) "Release" means any discharge, spillage, uncontrolled loss, seepage, filtration, leakage, injection, escape, dumping, pumping, pouring, emitting, emptying, or disposal of a substance.

(51) "Release area" means the land area at and beneath which polluted soil is located as a result of a release.

(52) "Remediation" means the containment, removal, mitigation, or abatement of pollution, a potential source of pollution, or a substance which poses a risk to human health or the environment, and includes but is not limited to the reduction of pollution by natural attenuation.

(53) "Residential activity" means any activity related to a (A) residence or dwelling, including but not limited to a house, apartment, or condominium, or (B) school, hospital, day care center, playground, or outdoor recreational area.

(54) "Residential direct exposure criteria" means the concentrations identified as residential direct exposure criteria in Appendix A to sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies.

(55) "Residential volatilization criteria" means the concentrations identified as residential volatilization criteria in Appendices E and F to sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies.

(56) "Seasonal high water table" means, on an annual basis, the highest plane in the ground at which plane all pore spaces are filled with water atmospheric pressure.

(57) "Seasonal low water table" means, on an annual basis, the lowest plane in the ground at which plane all pore spaces are filled with water atmospheric pressure.

(58) "Sediment" means unconsolidated material occurring in a stream channel, estuarine waters, or marine waters.

(59) "Seven day, ten year low flow" or "7Q10" means the lowest seven consecutive day mean stream discharge rate with a recurrence interval of ten (10) years.

(60) "Soil" means unconsolidated geologic material overlying bedrock, but not including sediment.

(61) "Soil water" means that portion of waters as defined in section 22a-423 of the General Statutes which portion is above the water table.

(62) "SPLP" means Synthetic Precipitation Leaching Procedure EPA Method 1312 as set forth in "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", SW-846, U.S. Environmental Protection Agency, Office of Solid Waste, Washington D.C. 20460.

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(63) "Substance" means an element, compound or material which, when added to air, water, soil or sediment, may alter the physical, chemical, biological or other characteristic of such air, water, soil or sediment.

(64) "Surface-water protection criteria" means the concentrations identified in Appendix D to sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies or any alternative surface-water protection criteria calculated or approved by the Commissioner in accordance with subdivision 22a-133k-3(b)(3) of the Regulations of Connecticut State Agencies.

(65) "TCLP" means Toxicity Characteristic Leaching Procedure EPA Method 1311 as set forth in "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", SW-846, U.S. Environmental Protection Agency, Office of Solid Waste, Washington D.C. 20460.

(66) "Technically practicable" means, with respect to remediation, the greatest degree of remediation that can be achieved using sound engineering and hydrogeologic practices.

(67) "Upgradient" means in the direction of maximum rate of increase of hydraulic head.

(68) "Upgradient area" with respect to a release area of a substance means the area bounded by (A) the width of the release area of such substance perpendicular to the direction of ground-water flow, (B) two side boundary lines parallel to the upgradient direction of ground-water flow extending from the two endpoints of said width to the upgradient parcel boundary, and (C) the upgradient parcel boundary extending between the two side boundary lines; excluding any portion of such upgradient area that is (i) affected by any other release of such substance or (ii) beneath an existing permanent structure.

(69) "Volatilization criteria" means the concentrations identified in Appendix E and Appendix F to sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies or alternative criteria approved by the Commissioner pursuant to subdivision 22a-133k-3(c)(4) of the Regulations of Connecticut State Agencies.

(70) "Volatilization criteria for ground water" means the concentrations identified in Appendix E to sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies.

(71) "Volatilization criteria for soil vapor" means the concentrations identified in Appendix F to sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies.

(72) "Water table" means the plane in the ground at which plane all pore spaces are filled with water at atmospheric pressure.

(73) "Water Quality Standards" means the latest adopted Connecticut Water Quality Standards and Criteria adopted by the Commissioner pursuant to section 22a-426 of the General Statutes.

(74) "Wetland" means 'wetlands' as defined in sections 22a-38(15) and section 22a-29(2) of the General Statutes.

(75) "Zone of influence" means zone of influence as defined in section 22a-430-3(a) of the Regulations of Connecticut State Agencies.

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(b) Applicability.

Sections 22a-133k-1 through 22a-133k-3, inclusive, of the Regulations of Connecticut State Agencies apply to any action taken to remediate polluted soil, surface water or a ground-water plume at or emanating from a release area which action is:

- (1) required pursuant to Chapter 445 or 446k of the General Statutes, or
- (2) taken pursuant to Public Act 95-183 or Public Act 95-190 including but not limited to any such action required to be taken or verified by a licensed environmental professional pursuant to such Public Acts.

Sections 22a-133k-1 through 22a-133k-3, inclusive, of the Regulations of Connecticut State Agencies do not apply within the zone of influence of a ground-water discharge permitted by the Commissioner under section 22a-430 of the General Statutes. Any person conducting a remediation in accordance with said sections 22a-133k-1 through 22a-133k-3, inclusive, of the Regulations of Connecticut State Agencies shall obtain all permits and other authorizations required by state, federal and local law and shall comply with all applicable state, federal and local laws, including without limitation the requirements of 40 CFR Part 761. In the event that any provision of sections 22a-133k-1 through 22a-133k-3, inclusive, of the Regulations of Connecticut State Agencies conflicts with any provision of any other statute or regulation, the more stringent provision shall prevail. Nothing in this subsection shall be construed as requiring any further remediation of any release which has been remediated and which remediation has been approved in writing by the Commissioner, unless the Commissioner takes action to require such remediation pursuant to any section of Chapter 446k of the General Statutes.

(c) Time frames for Issuance of Approvals by the Commissioner.

The Commissioner shall, no later than thirty days after the date of receipt of a request for his approval of any variance from or alternative criteria pursuant to sections 22a-133k-1 through 22a-133k-3, inclusive, of the Regulations of Connecticut State Agencies, provide to the requester in writing estimated time frames for the Commissioner to (1) determine whether additional information is needed for him to evaluate the request; and (2) approve or deny a complete request. In addition, no later than one hundred and eighty days following adoption of said sections 22a-133k-1 through 22a-133k-3, inclusive, of the Regulations of Connecticut State Agencies, the Commissioner shall make available general estimated written time frames for the Commissioner to approve any variance or alternative criterion pursuant to these regulations, including estimated time frames for the Commissioner to (1) determine whether additional information is needed to evaluate the request; and (2) approve or deny a complete request. In establishing estimated time frames pursuant to this subsection, the Commissioner shall take into account the complexity of the request, and the environmental and economic significance of the remediation, and shall expedite any request associated with any voluntary remediation pursuant to Public Acts 95-183 or 95-190.

(d) Public Participation.

(1) Public Hearing on Remediation. If the Commissioner determines that there is substantial public interest in any remediation proposed pursuant to section 2 of P.A. 95-190 or section 2 or 3 of P.A. 95-183, he may hold a public hearing on such proposed remediation, and he shall hold a hearing upon receipt of a petition signed by twenty-five or more persons. Notice of any such hearing shall be published in a newspaper of substantial circulation in the area of the proposed remediation at least thirty days prior to such hearing. Such hearing need not be conducted pursuant to the provisions of Chapter 54 of the General Statutes.

(2) Comment Procedures. Any public notice published or mailed pursuant to section 2 of P.A. 95-190 or section 2 or 3 of P.A. 95-183 shall provide that comments on the proposed remediation may be submitted to the Commissioner within forty-five days of the publication or mailing of such notice. The Commissioner shall forward a copy of all comments received by the date specified in the public notice and all comments made at a public hearing to the owner of the subject parcel and, if different, the person undertaking remediation at such parcel. The person undertaking remediation at the subject parcel shall, within sixty days of receiving such comments, submit to the Commissioner a written summary of all such comments and a written response to each such comment. The Commissioner shall review such summary and responses and shall adopt it as his own, adopt it with modifications, or reject it and prepare a response to each such comment. The

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Commissioner shall send a copy of the initial summary and responses and of his action with respect thereto to each person who submitted comments on the remediation proposal.

(e) Periodic review.

The Commissioner shall periodically review sections 22a-133k-1 through 22a-133k-3, inclusive, of the Regulations of Connecticut State Agencies to determine whether the implementation of such regulations is successfully protecting public health and the environment from the hazards of pollution. The Commissioner shall also evaluate whether the implementation of the regulations streamlines the process of conducting remediation projects in Connecticut, based upon, among other things, his review of the number of remediation projects completed in accordance with said sections 22a-133k-1 through 22a-133k-3, inclusive, of the Regulations of Connecticut State Agencies, the number of such projects reviewed by the Commissioner pursuant to sections 2 or 3 of P.A. 95-183, the length of time required for the Commissioner's review of complete requests for approval of alternative criteria or variances, and the number of remediation projects conducted pursuant to P.A. 95-190 or sections 2 or 3 of P.A. 95-183 which projects were verified by a licensed environmental professional. Such reviews shall be conducted at intervals of no more than five years, provided that nothing in this subsection shall preclude the Commissioner, at his discretion, from conducting such a review at any time and further provided that the first such review shall be conducted no later than eighteen months after the effective date of sections 22a-133k-1 through 22a-133k-3, inclusive, of the Regulations of Connecticut State Agencies. As a result of such a periodic review, the Commissioner may conclude that the goals of this subsection and section 22a-133k of the General Statute are being met, or he may conclude that revisions to such regulations are necessary to ensure that the implementation of said sections 22a-133k-1 through 22a-133k-3, inclusive, of the Regulations of Connecticut State Agencies achieves such goals, in which case he may revise such Regulations as he deems necessary to achieve those goals.

Section 2. The Regulations of Connecticut State Agencies are amended by adding a new section 22a-133k-2 as follows:

22a-133k-2 Standards for Soil Remediation

(a) General.

Unless otherwise specified in sections 22a-133k-1 through 22a-133k-3, inclusive, of the Regulations of Connecticut State Agencies, polluted soil at a release area shall be remediated to a concentration which meets (1) (A) the direct exposure criteria set forth in subsection (b) of this section or alternative direct exposure criteria established in accordance with subdivision (2) or subdivision (7) of subsection (d) of this section; and (B) the pollutant mobility criteria set forth in subsection (c) of this section or alternative pollutant mobility criteria established in accordance with subdivision (3) or (5) of subsection (d) of this section; or (2) the background concentration for soil provided notice has been submitted to the Commissioner which notice shall be submitted on a form furnished by the Commissioner and shall include a brief description of the subject release area and of the general characteristics of soils in the vicinity of such release area; a map showing the location of such release area, and based on reasonable inquiry of other release areas in the vicinity thereof, and of all soil samples taken for the purpose of characterizing background concentration for soil; and the results of all laboratory analyses of such samples.

(b) Direct Exposure Criteria.

(1) Except as otherwise provided in this paragraph, polluted soil at a release area shall be remediated to at least that concentration at which the residential direct exposure criteria for each substance is met.

(2) (A) Polluted soil at a release area may be remediated to a concentration at which the industrial/commercial direct exposure criteria for each substance except PCB is met if (i) access to the parcel containing such release area is limited to individuals working at or people temporarily visiting the subject parcel; and (ii) an environmental land use restriction is in effect with respect to such parcel, or to the portion of such parcel containing such

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release area, which environmental land use restriction ensures that the parcel or restricted portion thereof is not used for any residential activity in the future and that any future use of such parcel or restricted portion thereof is limited to an industrial or commercial activity.

(B) Soil polluted with PCB at a release area may be remediated to a concentration at which the industrial/commercial direct exposure criteria for PCB is met if the parcel upon which such release area is located is (i) an outdoor electrical substation as defined in 40 CFR 761.123; or (ii) an other restricted access location as defined in said section 40 CFR 761.123 and an environmental land use restriction is in effect with respect to such parcel, or to the portion of such parcel containing such release area, which environmental land use restriction ensures that the parcel or restricted portion thereof is not used for any residential activity in the future and that any future use of such parcel or restricted portion thereof is limited to an industrial or commercial activity.

(3) The direct exposure criteria for substances other than PCB do not apply to inaccessible soil at a release area provided that if such inaccessible soil is less than 15 feet below the ground surface an environmental land use restriction is in effect with respect to the subject parcel or to the portion of such parcel containing such release area, which environmental land use restriction ensures that such soils will not be exposed as a result of excavation, demolition or other activities and that any pavement which is necessary to render such soil inaccessible is maintained in good condition unless and until such restriction is released in accordance with said section 22a-133q-1. Unless an alternative criterion has been approved in accordance with subsection 22a-133k-2(d)(7), inaccessible soil polluted with PCB may be remediated to a concentration of 10 ppm PCB by weight provided that (A) if such inaccessible soil is located on a parcel which is an other restricted access location as defined in said section 40 CFR 761.123, such soil may be remediated to a concentration of 25 ppm PCB by weight, or (B) if such inaccessible soil is located on a parcel which is an outdoor electrical substation as defined in 40 CFR 761.123, such soil may be remediated to a concentration of 25 ppm PCB by weight, or if a label or notice is visibly placed in the area in accordance with 40 CFR Part 761, to a concentration of 50 ppm PCB by weight.

(4) Additional Polluting Substances

(A) With respect to a substance at a release area for which a direct exposure criterion is not specified in sections 22a-133k-1 through 22a-133k-3, inclusive, of the Regulations of Connecticut State Agencies, the Commissioner may, after consultation with the Commissioner of Public Health, approve in writing a direct exposure criterion to apply to such substance at a particular release area. Any person requesting approval of a direct exposure criterion for such substance shall submit to the commissioner (i) a proposed risk-based direct exposure concentration for such substance calculated in accordance with subparagraph (B) or (C) of this subdivision as applicable, and (ii) the analytical detection limit for such substance. Before approving a direct exposure criterion the Commissioner shall consider the proposed risk-based direct exposure concentration for such substance, the analytical detection limit for such substance, any information about the health effects such substance may cause due to exposure pathways not accounted for in the proposed risk-based direct exposure, and any other information that the Commissioner reasonably deems necessary.

(B) The proposed residential risk-based direct exposure concentration shall be calculated using the following equations:

(i) For carcinogenic substances:

$$DEC_{RB} = \left[\frac{\text{Risk}}{\text{CSF}} \right] \times \left[\frac{BW_C \times AT}{IR_C \times ED_C \times EF \times CF} + \frac{BW_A \times AT}{IR_A \times ED_A \times EF \times CF} \right]$$

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(ii) For non-carcinogenic substances:

$$DEC_{RB} = \left[RFD \times HI \right] \times \left[\frac{BW_C \times AT_C}{IR_C \times ED_C \times EF \times CF} + \frac{BW_A \times AT}{IR_A \times ED_A \times EF \times CF} \right]$$

(iii) The abbreviations used in subparagraphs (i) and (ii) shall be interpreted in accordance with the following table and shall be assigned the values specified therein:

Term	Description	Units	Value
DEC_{RB}	Risk-based Direct Exposure Criterion	mg/kg	calculated
Risk	Target Cancer Risk Level	unitless	1.0E-06
HI	Hazard Index	unitless	1.0
CSF	Cancer slope Factor	(mg/kg-day) ⁻¹	substance-specific
RFD	Reference Dose	mg/kg-day	substance-specific
IR_C	Ingestion Rate, Child	mg/day	200
IR_A	Ingestion Rate, Adult	mg/day	100
EF	Exposure Frequency	days/year	365
ED_C	Exposure Duration, Child	years	6
ED_A	Exposure Duration, Adult	years	24
CF	Conversion Factor	kg/mg	0.000001
BW_C	Body Weight, Child	kg	15
BW_A	Body Weight, Adult	kg	70
AT	Averaging Time, for carcinogens	days	25550
AT_C	Averaging Time, Child for non-carcinogens	days	2190
AT_A	Averaging Time, Adult for non-carcinogens	days	8760

(C) The proposed industrial/commercial risk-based direct exposure concentration shall be calculated using the following equations:

(i) For carcinogenic substances:

$$DEC_{RB} = \left[\frac{\text{Risk}}{\text{CSF}} \right] \times \left[\frac{BW \times AT}{IR \times ED \times EF \times CF} \right]$$

(ii) For non-carcinogenic substances:

$$DEC_{RB} = \left[RFD \times HI \right] \times \left[\frac{BW \times AT}{IR \times EF \times ED \times CF} \right]$$

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(iii) The abbreviations used in subparagraphs (i) and (ii) shall be interpreted in accordance with the following table and shall be assigned the values specified therein:

Term	Description	Units	Value
DEC _{RB}	Risk-based Direct Exposure Criterion	mg/kg	calculated
Risk	Target Cancer Risk Level	unitless	1.0E-06
HI	Hazard Index	unitless	1.0
CSF	Cancer slope Factor	(mg/kg-day) ⁻¹	substance-specific
RFD	Reference Dose	mg/kg-day	substance-specific
IR	Ingestion Rate	mg/day	50
EF	Exposure Frequency	days/year	250
ED	Exposure Duration	years	25
CF	Conversion Factor	kg/mg	0.000001
BW	Body Weight	kg	70
AT	Averaging Time, for carcinogens	days	25550
AT _A	Averaging Time, Adult for non-carcinogens	days	9125

(c) Pollutant Mobility Criteria.

(1) General.

(A) A substance, other than an inorganic substance or PCB, in soil above the seasonal low water table, or above the seasonal high water table if (i) remediation to the seasonal low water table is not technically practicable or would not result in the permanent elimination of a source of pollution or (ii) the subject soil is located in a GB area, shall be remediated to at least that concentration at which the results of a mass analysis of such soil for such substance does not exceed the pollutant mobility criterion applicable to the ground-water classification of the area at which such soil is located, except that in the circumstances identified in subdivision (2) of this subsection, remediation to achieve compliance with the pollutant mobility criteria may be conducted in accordance with the requirements established in said subdivision (2).

(B) An inorganic substance or PCB in soil above the seasonal low water table, or above the seasonal high water table if (i) remediation to the seasonal low water table is not technically practicable or would not result in the permanent elimination of a source of pollution or (ii) the subject soil is located in a GB area, shall be remediated to at least that concentration at which the results of a TCLP or SPLP analysis of such soil for such substance does not exceed the pollutant mobility criterion applicable to the ground-water classification of the area at which such soil is located, except that in the circumstances identified in subdivision (2) of this subsection, remediation to achieve compliance with the pollutant mobility criteria may be conducted in accordance with the requirements established in said subdivision (2).

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(2) Specific Circumstances

(A) Polluted Soils in a GA Area.

A soil in a GA area and polluted with a substance, other than 1,2 dichlorobenzene, ethyl benzene, toluene, xylenes or total petroleum hydrocarbons, which soil is at or above the seasonal low water table, or at or above the seasonal high water table if remediation to the seasonal low water table is not technically practicable or would not result in the permanent elimination of a source of pollution, may be remediated to at least that concentration at which the results of a TCLP or SPLP analysis of such soil for such substance do not exceed the ground-water protection criterion for such substance.

(B) Soils Polluted with Volatile Organic Substances in a GA area.

A soil in a GA area polluted with a volatile organic substance, other than 1,2 dichlorobenzene, ethyl benzene, toluene, or xylenes which soil is at or above the seasonal low water table, or at or above the seasonal high water table if remediation to the seasonal low water table is not technically practicable or would not result in the permanent elimination of a source of pollution, may be remediated to at least that concentration at which the results of a TCLP or SPLP analysis of such soil for such substance do not exceed the ground-water protection criterion for such substance multiplied by ten or the results of a mass analysis of such soil for such substance do not exceed the pollutant mobility criterion for such substance multiplied by ten or by an alternative dilution or dilution and attenuation factor approved by the Commissioner in accordance with subdivision (4) of subsection (d) of this section, provided no non-aqueous phase liquids are present in the subject release area as determined in accordance with subdivision (3) of this subsection, the water table is at least fifteen feet above the surface of the bedrock and the downward vertical flow velocity is not greater than the horizontal flow velocity, and:

(i) (aa) a public water supply distribution system is available within 200 feet of the subject parcel, all adjacent parcels, and any parcel within the areal extent of the ground-water plume caused by the subject release area, (bb) the ground water within the areal extent of such ground-water plume is not used for drinking water, (cc) no public or private water supply wells exist within 500 feet of the subject release area, and (dd) the ground water affected by the subject release area is not a potential public water supply resource; or

(ii) (aa) the concentration of any volatile organic substance in a ground-water plume and within seventy-five feet of the nearest downgradient parcel boundary does not exceed the ground-water protection criterion, (bb) except for seasonal variation, the areal extent of volatile organic substances in the ground-water plume is not increasing over time and the concentration of any volatile organic substance in the ground-water plume is not increasing, except as a result of natural attenuation, at any point over time and (cc) notice of such condition is provided to the Commissioner on a form furnished by the Commissioner, which notice shall include: a brief description of the release area; a brief description of the distribution and concentration of volatile organic substances in soil and ground water; a map showing the location of the release area, and based on reasonable inquiry all other volatile organic substance release areas in the vicinity of the subject release area, all ground-water and soil monitoring points, and the areal extent of the volatile organic substance ground-water plume; and the results of all laboratory analyses conducted to determine whether the requirements of this subparagraph have been met; or

(iii) (aa) the concentration of any volatile organic substance within such ground-water plume does not exceed the ground-water protection criterion for such substance at a location downgradient of the release area, on the subject parcel, and within 25 feet of such release area, and (bb) notice of such condition is provided

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to the Commissioner on a form furnished by the Commissioner, which notice shall include: a brief description of the release area; a brief description of the distribution and concentration of volatile organic substances in soil and ground water; a map showing the location of the release area, and based on reasonable inquiry all other volatile organic substance release areas in the vicinity of the subject release area, and all ground-water and soil monitoring points; and the results of all laboratory analyses conducted to determine whether the requirements of this subparagraph have been met.

(C) Inorganic, semi-volatile, PCB or pesticide contamination in a GA area.

A soil in a GA area and polluted with inorganic substances, semi-volatile substances, PCB or pesticides, which soil is at or above the seasonal low water table, or at or above the seasonal high water table if remediation to the seasonal low water table is not technically practicable or would not result in the permanent elimination of a source of pollution, may be remediated to a level at which (i)(aa) the results of a TCLP or SPLP analysis of such soil for such substance do not exceed the ground-water protection criterion for such substance multiplied by ten or by an alternative dilution or dilution and attenuation factor approved by the Commissioner in accordance with subdivision (4) of subsection (d) of this section or (bb) the results of a mass analysis of such soil for a substance do not exceed the pollutant mobility criterion for such substance multiplied by ten or by an alternative dilution or dilution and attenuation factor approved by the Commissioner in accordance with subdivision (4) of subsection (d) of this section; provided (ii) (aa) the release area and any portion thereof is located at least twenty-five feet from the nearest legal boundary of the parcel in the downgradient direction, (bb) no non-aqueous phase liquids are present in the release area as determined in accordance with subdivision (3) of this subsection, and (cc) the water table is at least fifteen feet above the surface of the bedrock.

(D) Polluted Soils in a GB area.

A substance other than total petroleum hydrocarbons in soil above the seasonal high water table in a GB area may be remediated to a level at which the results of a TCLP or SPLP analysis of such soil does not exceed the ground-water protection criterion for any such substance (i) (aa) multiplied by 10, (bb) multiplied by the ratio of the summation of the areas downgradient and upgradient of the release area to the release area, provided that such ratio does not exceed 500, or (cc) or multiplied by an alternative dilution or dilution and attenuation factor approved by the Commissioner in accordance with subdivision (5) of subsection (d) of this section; (ii) provided non-aqueous phase liquids are not present in such soil as determined in accordance with subdivision (3) of this subsection.

(E) Site specific dilution in a GB area.

(i) A substance, other than total petroleum hydrocarbons, in a soil at or above the seasonal high water table in a GB area where the background concentration for ground water for such substance is less than the applicable ground-water protection criterion, may be remediated to a level at which the results of a mass analysis of such soil for a substance do not exceed the pollutant mobility criterion applicable to such substance in a GA area multiplied by a site-specific dilution factor calculated in accordance with clause (ii) of this subparagraph, or the results of a TCLP or SPLP analysis of such soil for a substance do not exceed the ground-water protection criterion for such substance multiplied by a site-specific dilution factor calculated in accordance with clause (ii) of this subparagraph, provided (aa) no non-aqueous phase liquids are present in such soil as determined in accordance with subdivision (3) of this subsection; (bb) notice has been submitted to the Commissioner in accordance with clause (iii) of this subparagraph; and (cc) the water table in the release area is at least fifteen feet above the surface of the bedrock and the downward ground water vertical flow velocity is not greater than the ground water horizontal flow velocity.

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(ii) For the purpose of clause (i) of this subparagraph, the site-specific dilution factor shall be calculated using the following formula: $DF = (1 + (Kd/IL))(1 - F_{adj})$, where:

DF = site-specific dilution factor
K = hydraulic conductivity, in feet per year, of the unconsolidated aquifer underlying the release area
i = horizontal hydraulic gradient in feet per foot
d = 15 feet
I = infiltration rate in feet per year as specified in subparagraph (iv) of this subparagraph
L = length in feet of the release area parallel to the direction of ground-water flow
 F_{adj} = background concentration for ground water divided by the ground-water protection criterion for the subject substance, or, where the background concentration for ground water can not be quantified, $\frac{1}{2}$ the minimum detection limit for the subject substance divided by the ground-water protection criterion for the subject substance.

(iii) A notice submitted pursuant to clause (i) of this subparagraph shall be submitted on a form prescribed and provided by the Commissioner and shall include: a brief description of the release area and the general characteristics of soils in the vicinity of the release area; a map showing the location of the release area, and based on reasonable inquiry other release areas in the vicinity containing the substance for which the site-specific dilution factor is calculated, and all monitoring points; if applicable, justification for use of a till infiltration rate other than 0.5 feet per year, and the results of all the laboratory analyses and field analyses used to determine the (aa) parameters of the equation in clause (ii) of this subparagraph and (bb) identification of geologic material for the purposes of choosing an infiltration rate in accordance with clause (iv) of this subparagraph.

(iv)

Geologic Material	Infiltration Rate (feet/year)
Stratified Drift	2.0
Till	0.5 - 1.0
Lacustrine Deposits	0.4

(3) Determining the Presence of Non-aqueous Phase Liquids in Soil. For the purpose of this subsection, the presence of non-aqueous phase liquids in soil shall be determined using the following equation: $C_{nnp} = (S/2\rho_b)(K_d\rho_b + \theta_w + H'\theta_a)$, where:

C_{nnp} = the concentration of an organic substance at which or above which such substance may be present in a non-aqueous phase
S = the effective solubility
 ρ_b = dry soil bulk density
 K_d = soil-water partition coefficient, which may be approximated by $K_{oc} \cdot f_{oc}$
 K_{oc} = soil organic carbon-water partition coefficient
 f_{oc} = fraction organic carbon of soil
 θ_w = water-filled soil porosity (L_{water}/L_{soil})
 θ_a = air-filled soil porosity (L_{air}/L_{soil})
H' = Henry's law constant (dimensionless)
H = Henry's law constant (atm-m³/mol)

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The terms defined above shall be assigned the following values:

Term	Units	Value
C_{NAP}	mg/kg	calculated
S	mg/L	chemical-specific
ρ_b	kg/L	1.5 or the lowest value measured at the subject release area
K_d	L/kg	calculated
K_{OC}	L/kg	chemical-specific
f_{OC}	g/g	0.006 or the lowest value measured at the subject release area
θ_w	L_{water}/L_{soil}	0.15
θ_a	L_{air}/L_{soil}	0.28
H'	unitless	$H \times 41$ where 41 is a conversion factor
H	atm-m ³ /mol	chemical-specific

(4) Exceptions.

(A) If at a release area (i) the ground-water classification is GB and (ii) the elevation of the water table is below the elevation of the top of bedrock, such release area shall be remediated to a concentration which meets the pollutant mobility criteria applicable to any location at which the ground-water classification is GA or GAA.

(B) The pollutant mobility criteria do not apply to environmentally isolated soil provided an environmental land use restriction is in effect with respect to the parcel, or portion thereof, containing such soil which environmental land use restriction ensures that such soil will not be exposed to infiltration of soil water due to, among other things, demolition of the building.

(C) The pollutant mobility criteria do not apply to polluted fill on a parcel if: (aa) such fill is polluted only with coal ash, wood ash, coal fragments, asphalt paving fragments, or any combination thereof; (bb) such fill is not polluted with any volatile organic substance; (cc) the concentration of each substance in any such fill is consistent with the requirements established in subsection (b) of this section; (dd) such substance is not affecting and will not affect the quality of an existing or potential public water supply resource or an existing private drinking water supply; (ee) a public water supply distribution system is available within 200 feet of such parcel and all parcels adjacent thereto; and (ff) the placement of the fill was not prohibited by law at the time of placement.

(5) Additional Polluting Substances.

With respect to a substance for which a pollutant mobility criterion is not specified in sections 22a-133k-1 through 22a-133k-3, inclusive, of the Regulations of Connecticut State Agencies, the Commissioner may approve a pollutant mobility criterion, a dilution or dilution and attenuation factor, and a method for determining compliance with such criterion to apply to such substance at a particular release area, provided he finds that such criterion will ensure that soil water at such

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release area does not exceed, in a GA area, the ground-water protection criterion, or in a GB area the ground-water protection criterion multiplied by a dilution factor of 10.

(d) Alternative Soil Criteria.

(1) Requests for Approval of Alternative Soil Criteria.

(A) Any person requesting that the Commissioner approve an alternative criterion applicable to a particular release area shall submit: the name and address of the owner of the parcel at which such release area is located; the address of such release area and a brief description of its location; a detailed description of such release area; and a map at a scale of not less than 1:1200 showing the location of all release areas on such parcel, the subject release area, and describing the concentration and distribution of all substances in the soil of the subject release area, including but not limited to the substance for which an alternative criterion is sought; a detailed written report describing the justification for the proposed alternative criterion; and any other information the Commissioner reasonably deems necessary to evaluate such request.

(B) Any person requesting that the Commissioner approve an alternative pollutant mobility criterion or an alternative dilution or dilution attenuation factor shall submit, in addition to the information required by subparagraph (A) of this subdivision, a detailed description of any other release area located on the same parcel as the subject release area and which other release area (i) is affected or potentially affected by the subject release area or (ii) is affecting or potentially may affect the subject release area;

(C) Any person requesting that the Commissioner approve an alternative direct exposure criterion shall submit, in addition to the information required by subparagraph (A) of this subdivision, a detailed description of any other release area located on the same parcel as the subject release area.

(2) Alternative Direct Exposure Criteria.

With respect to a substance except PCB for which a direct exposure criterion is specified in sections 22a-133k-1 through 22a-133k-3, inclusive, of the Regulations of Connecticut State Agencies, the Commissioner may approve an alternative direct exposure criterion and an alternative method for determining compliance with such criterion provided it is demonstrated to the satisfaction of the Commissioner, after consultation with the Commissioner of Public Health that the application of such alternative criterion at the subject release area will protect human health and the environment from the risks associated with direct exposure to polluted soil by ensuring that (A) the concentration of each carcinogenic substance in such soil does not exceed a 1×10^{-6} excess lifetime cancer risk level and the concentration of each non-carcinogenic substance in such soil does not exceed a hazard index of 1; or (B) for a release area polluted with multiple substances, the cumulative excess lifetime cancer risk for all carcinogenic substances in such soil does not exceed 1×10^{-5} and the cumulative hazard index does not exceed 1 for non-carcinogenic substances in such soil with the same target organ. Any person requesting approval of an alternative direct exposure criterion shall submit to the Commissioner and the Commissioner of Public Health a risk assessment prepared in accordance with the most recent EPA Risk Assessment Guidance for Superfund or other risk assessment method approved by the Commissioner in consultation with the Commissioner of Public Health, and shall submit any additional information specified by the Commissioner or the Commissioner of Public Health.

(3) Alternative Pollutant Mobility Criteria for GA Areas.

With respect to a substance occurring at a release area located in a GA area, and for which substance a pollutant mobility criterion is specified in sections 22a-133k-1 through 22a-133k-3, inclusive, of the Regulations of Connecticut State Agencies, the Commissioner may approve an alternative pollutant mobility criterion and an alternative method for determining compliance with such criterion, provided it is demonstrated to the Commissioner's satisfaction that the application

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of such alternative criterion at the subject release area will ensure that soil water at such release area will not exceed the ground-water protection criterion for such substance.

(4) Alternative Dilution or Dilution Attenuation Factor for GA Areas.

With respect to a substance occurring at a release area located in a GA area, and for which substance a pollutant mobility criterion is specified in sections 22a-133k-1 through 22a-133k-3, inclusive, of the Regulations of Connecticut State Agencies, the Commissioner may approve an alternative dilution or dilution attenuation factor, provided that it is demonstrated to the Commissioner's satisfaction that application of such dilution factor will ensure that such release area will not degrade ground-water quality and thereby prevent the achievement of the applicable ground-water remediation standards.

(5) Alternative Pollutant Mobility Criteria for GB Areas.

With respect to a substance occurring at a release area located in a GB area, and for which substance a pollutant mobility criterion is specified in sections 22a-133k-1 through 22a-133k-3, inclusive, of the Regulations of Connecticut State Agencies, the Commissioner may approve an alternative pollutant mobility criterion and an alternative method for determining compliance with such criterion at such release area, provided it is demonstrated to the Commissioner's satisfaction that the application of such criterion will ensure that soil water at the release area, after dilution with ground water derived from infiltration on the parcel, will not exceed the ground-water protection criterion for such substance.

(6) Alternative Dilution or Dilution Attenuation Factor for GB Areas.

With respect to a substance occurring at a release area located in a GB area, and for which substance a pollutant mobility criterion is specified in sections 22a-133k-1 through 22a-133k-3, inclusive, of the Regulations of Connecticut State Agencies, the Commissioner may approve an alternative dilution or dilution attenuation factor, provided that it is demonstrated to the Commissioner's satisfaction that application of such alternative dilution or dilution attenuation factor will ensure that the soil water at such release area will not cause the ground water at the nearest downgradient property boundary to exceed the ground-water protection criterion for such substance.

(7) Alternative Direct Exposure Criterion for PCB.

The Commissioner may approve an alternative direct exposure criterion for PCB including an alternative direct exposure criterion for an inaccessible soil polluted with PCB, and an alternative method for determining compliance with such criterion, provided it is demonstrated to the satisfaction of the Commissioner after consultation with the Commissioner of Public Health that the application of such alternative criterion at the subject release area will protect human health and the environment from the risks associated with direct exposure to soil polluted with PCB and is consistent with 40 CFR Part 761 and with the "Guide on Remedial Actions at Superfund Sites with PCB Contamination" (EPA Directive 9355.4-01, August 1990).

(e) Applying the Direct Exposure and Pollutant Mobility Criteria

(1) Unless an alternative method for determining compliance with a direct exposure criterion has been approved by the Commissioner in writing, compliance with a direct exposure criterion is achieved when (A) the ninety-five percent upper confidence level of the arithmetic mean of all sample results of laboratory analyses of soil from the subject release area is equal to or less than such criterion, provided that the results of no single sample exceeds two times the applicable direct exposure criterion or (B) the results of all laboratory analyses of samples from the subject release area are equal to or less than the applicable direct exposure criterion.

(2) Unless an alternative method for determining compliance with a pollutant mobility criterion for a particular substance has been approved by the Commissioner in writing, compliance with a

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pollutant mobility criterion for such substance is achieved when:

(A) (i) a representative sampling program consisting of not less than twenty samples of soil located above the water table has been used to characterize the distribution and concentration of such substance at the subject release area or remaining at the subject release area following remediation, (ii) the release area has not been remediated by means of excavation and removal of polluted soil, (iii) the ninety-five percent upper confidence level of the arithmetic mean of all the sample results of laboratory analyses of soil from the subject release area for such substance is equal to or less than the applicable pollutant mobility criterion or the results of all laboratory analyses of samples from the subject release area are equal to or less than the applicable direct exposure criterion, and (iv) no single sample result exceeds two times the applicable pollutant mobility criterion;

(B) (i) a representative sampling program consisting of less than twenty samples of soil located above the water table has been used to characterize the distribution and concentration of substances remaining at the subject release area following remediation, (ii) the release area has not been remediated by means of excavation and removal of polluted soil, and (iii) the results of all laboratory analysis of samples from the subject release area for such substances are equal to or less than such pollutant mobility criterion; or

(C) (i) the subject release area has been remediated by means of excavation and removal of polluted soil, (ii) a representative sampling program consisting of samples of soil located above the water table has been used to characterize the distribution and concentration of substances remaining at the subject release area following excavation and removal, and (iii) the results of all laboratory analyses of samples from the subject release area for such substances are equal to or less than such pollutant mobility criterion.

(3) Matrix interference effects.

If any applicable criterion for a substance in soil is less than the concentration for such substance that can be consistently and accurately quantified in a specific sample due to matrix interference effects, the following actions shall be taken:

(A) (i) "Test Methods for Evaluating Solid Waste : Physical/Chemical Methods," SW-846, U.S. Environmental Protection Agency, Office of Solid Waste, Washington D.C. 20460 shall be consulted to determine if an analytical method sufficiently sensitive to achieve the applicable analytical detection limit was used to conduct the analysis of the subject substance. If there is available an alternative analytical method which is sufficient to achieve the required analytical detection limit, appropriate for the sample matrix, and has been approved by EPA or approved in writing by the Commissioner, the subject soil shall be re-analyzed for the subject substance using such alternative method.

(ii) If a sample has been analyzed by one or more analytical methods in accordance with subparagraph (A)(i) of this subdivision and the applicable analytical detection limit has not been achieved due to matrix interference effects, such method(s) shall be modified in order to compensate for such interferences, in accordance with analytical procedures specified by EPA within the scope of the analytical method.

(B) If, after re-analyzing the subject soil and attempting to compensate for matrix interference effects in accordance with to subparagraph (A) of this subdivision, any applicable criterion for a substance in soil is less than the concentration for such substance that can be consistently and accurately quantified in a specific sample due to matrix interference effects, compliance with such criterion shall be achieved when such soil has been remediated to the lowest concentration for such substance which can be consistently and accurately quantified without matrix interference effects.

(C) A detailed summary of all measures taken to overcome matrix interference effects and a determination of the lowest alternative quantification level applicable to the analysis of

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such substance shall be prepared and, if requested by the Commissioner in writing, shall be submitted to the Commissioner for his review and approval.

(f) Variances.

(1) Widespread Polluted Fill.

The Commissioner may grant a variance from any of the requirements of subsection (c) of this section upon the written request of the owner of the subject parcel if the Commissioner determines that (A) geographically extensive polluted fill is present at such parcel and at other parcels in the vicinity of the subject parcel; (B) such fill is not polluted with volatile organic substances; (C) such fill is not affecting and will not affect the quality of an existing or potential public water supply resource or an existing private drinking water supply; (D) the concentration of each substance in such fill is consistent with subsection (b) of this section; (E) the placement of such fill was not prohibited by law at the time of placement; and (F) the person requesting the variance did not place the fill on the subject parcel. In determining whether to grant or deny such a variance, the Commissioner may consider the relative cost of compliance with subsection (c) of this section, how extensive the polluted fill is, what relative proportion of such fill occurs on the subject parcel, and whether the person requesting the variance is affiliated with any person responsible for such placement through any direct or indirect familial relationship or any contractual, corporate or financial relationship other than that by which such person's interest in such parcel is to be conveyed or financed.

(2) Engineered Control of Polluted Soils.

(A) Provided that an engineered control of polluted soils is implemented pursuant to subparagraphs (B) and (C) of this subsection, the requirements of subsections (a) through (e) of this section do not apply if:

(i) the Commissioner authorized the disposal of solid waste or polluted soil at the subject release area;

(ii) the soil at such release area is polluted with a substance for which remediation is not technically practicable;

(iii) the Commissioner, in consultation with the Commissioner of Public Health, has determined that the removal of such substance or substances from such release area would create an unacceptable risk to human health; or

(iv) the Commissioner has determined, after providing notice and an opportunity for a public hearing, that a proposal by the owner of the subject parcel to use an engineered control is acceptable because (aa) the cost of remediating the polluted soil at such release area is significantly greater than the cost of installing and maintaining an engineered control for such soil and conducting ground-water monitoring at such release area in accordance with subsection (g) of section 22a-133k-3, and (bb) that the significantly greater cost outweighs the risk to the environment and human health if the engineered control fails to prevent the mobilization of a substance in the soil or human exposure to such substance. The Commissioner may hold a public hearing pursuant to this section if in his discretion the public interest will be best served thereby, and he shall hold a hearing upon receipt of a petition signed by at least twenty-five persons. Notice of the subject proposal shall be provided by the owner of the subject parcel in two of the three following manners: (i) by publication in a newspaper of substantial circulation in the affected area; (ii) by placing and maintaining on the subject parcel, for at least thirty days, in a legible condition a sign which shall be not less than six feet by four feet which sign shall be clearly visible from the public highway; or (iii) by mailing notice to the owner of record of each property abutting the subject parcel at his address on the most recent grand tax list of the

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municipality or municipalities in which such properties are located. When notice is published or mailed, it shall include the name and address of owner of the subject parcel; the location address and/or a description of the location such parcel; a brief description of the nature of the pollution on the subject parcel; a brief description of the proposed engineered control; and a brief description of the procedures for requesting a hearing. When notice is provided by posting a sign, the sign shall include the words "Environmental remediation is proposed for this site. For further information contact..." and shall include the name and telephone number of an individual from whom any interested person may obtain information about the remediation. The owner of the subject parcel shall verify to the Commissioner in writing on a form furnished by him that notice has been given in accordance with this subsection.

(B) A request to use an engineered control shall be submitted to the Commissioner in writing and shall be accompanied by a detailed written report and plan which demonstrates that:

- (i) (aa) the proposed engineered control is designed and will be constructed to physically isolate polluted soil and to minimize migration of liquids through soil, to function with minimum maintenance, to promote drainage and minimize erosion of or other damage to such control, and to accommodate settling and subsidence of the underlying soil so as to maintain the control's structural integrity and permeability; and (bb) with respect to an engineered cap, such cap has been designed and constructed to have a permeability of less than 10^{-6} cm/sec or, unless otherwise specified by the Commissioner in writing, to have the permeability specified in a closure plan implemented under sections 22a-209-1 *et seq* of the Regulations of Connecticut State Agencies for a release area which is a lawfully authorized solid waste disposal area;
- (ii) plans for ground-water monitoring at the subject release area are adequate to ensure that any substance migrating therefrom will be detected;
- (iii) plans for maintenance of the subject release area are adequate to ensure that the structural integrity, design permeability, and effectiveness of the engineered control will be maintained; such plans shall include without limitation measures to prevent run-on and run-off of storm water from eroding or otherwise damaging the engineered control and measures to repair such control to correct the effects of any settling, subsidence, erosion or other damaging events or conditions;
- (iv) an environmental land use restriction is or will be in effect with respect to the parcel at which the subject release area is located, which restriction ensures that such parcel will not be used in a manner that could disturb the engineered control or the polluted soil;
- (v) any other information that the Commissioner reasonably deems necessary; and
- (vi) with respect to any release area subject to any of the requirements of section 22a-209-4(i) or section 22a-449(c)-100 through 110 of the Regulations of Connecticut State Agencies, all such requirements are or will be satisfied. With respect to a release area which is not subject to any such regulations, the owner of the subject parcel shall demonstrate that he has posted or will post a surety in a form and amount approved in writing by the Commissioner, which surety during the first year after installation of the engineered control shall be equal to the cost of one year's maintenance and monitoring of the engineered control, and which in each subsequent year shall be increased in amount by adding an amount equal to the cost of one year's maintenance and monitoring, until the total amount of such surety is equal to the cost of five year's of maintenance and monitoring, which amount shall be maintained in effect for the next twenty-five years or for such other period as may be required by the Commissioner.

(C) When the Commissioner approves a request pursuant to this subsection to use an engineered control he may require that such control incorporate any measures which he deems necessary to protect human health and the environment. Any person implementing

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an engineered control under this subsection shall perform all actions specified in the approved engineered control proposal including the recordation of the environmental land use restriction and posting of the surety, and any additional measures specified by the Commissioner in his approval of such plan. Nothing in this subdivision shall preclude the Commissioner from taking any action he deems necessary to protect human health or the environment if an approved engineered control fails to prevent the migration of pollutants from the release area or human exposure to such pollutants.

(g) Removal of Non-aqueous Phase Liquids.

Removal of light non-aqueous phase liquids from soil and ground water shall be conducted in accordance with section 22a-449(d)-106(f) of the Regulations of Connecticut State Agencies. Any other non-aqueous phase liquid shall be contained or removed from soil and ground water to the maximum extent prudent.

(h) Use of Polluted Soil and Reuse of Treated Soil.

Any soil excavated from and/or treated at a release area during remediation shall be managed as follows:

(1) Hazardous Waste.

Treatment, storage, disposal and transportation of soil which is hazardous waste as defined pursuant to section 22a-449(c) of the General Statutes shall be carried out in conformance with the provisions of sections 22a-449(c)-101 through 110 of the Regulations of Connecticut State Agencies, and any other applicable law;

(2) Special Wastes.

In accordance with section 22a-209-8 of the Regulations of Connecticut State Agencies, the Commissioner may authorize polluted soil, which is not hazardous waste as defined pursuant to subsection 22a-449(c) of the General Statutes, to be disposed of as special wastes as defined in said section 22a-209-1.

(3) Polluted soil.

Polluted soil from a release area may be treated to achieve concentrations of substances that do not exceed either the applicable direct exposure criteria or pollutant mobility criteria. After such treatment, such soil may be reused on the parcel from which it was excavated or on another parcel approved by the Commissioner, provided that such reuse is consistent with all other provisions of sections 22a-133k-1 through 22a-133k-3, inclusive, of the Regulations of Connecticut State Agencies and:

- (A) Prior to reuse, a map showing the location and depth of proposed placement of such soil is submitted to the Commissioner;
- (B) Such soil is not placed below the water table;
- (C) Such soil is not placed in an area subject to erosion; and
- (D) Any such soil in which the concentration of any substance exceeds the pollutant mobility criteria applicable to a GA area is not placed over soil and ground water which have not been affected by a release at the parcel at which placement is proposed; and
- (E) For soils polluted with PCB, the Commissioner has issued a written approval in accordance with by section 22a-467 of the General Statutes.

(4) Natural Soil.

Polluted soil may be used at any parcel of land if after treatment of such soil to reduce or remove substances: (A) any naturally-occurring substance is present therein in concentrations not exceeding background concentration for soil of such substance at the release area from which such soil is removed; and (B) no other substance is detectable in such soil at a concentration greater than its analytical detection limit.

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(i) Additional remediation of soil.

Nothing in sections 22a-133k-1 through 22a-133k-3, inclusive, of the Regulations of Connecticut State Agencies shall preclude the Commissioner from taking any action necessary to prevent or abate pollution or to prevent or abate any threat to human health or the environment, including without limitation:

- (1) at any location at which, despite remediation in accordance with sections 22a-133k-1 through 22a-133k-3, inclusive, of the Regulations of Connecticut State Agencies, the Commissioner determines that there is a potential ecological risk he may require that an ecological risk assessment be conducted in accordance with EPA/630/R-92/001, February 1992, "Framework For Ecological Risk Assessment" and that additional remediation be conducted to mitigate any risks identified in such assessment;
- (2) at any location at which polluted soil has eroded into a surface-water body, the Commissioner may require that the effect of such polluted soil on aquatic life be assessed and that remediation to protect or restore aquatic life and surface water quality from the effects of such polluted soils be undertaken; or
- (3) at any release area or parcel at which there is polluted soil containing multiple polluting substances, the Commissioner may require additional remediation to ensure that the risk posed by such substances does not exceed (A) a cumulative excess lifetime cancer risk of 10^{-5} for carcinogenic substances and (B) a cumulative hazard index of 1 for non-carcinogenic substances with the same target organ.

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Section 3. The Regulations of Connecticut State Agencies are amended by adding a new section 22a-133k-3 as follows:

22a-133k-3 Ground-water Remediation Standards

(a) General.

(1) Remediation of a ground-water plume shall result in the attainment of: (A) the requirements concerning surface water protection set forth in subsection (b) of this section and the requirements concerning volatilization set forth in subsection (c) of this section; or (B) the background concentration for ground water for each substance in such plume.

(2) Remediation of a ground-water plume in a GA area shall also result in the reduction of each substance therein to a concentration equal to or less than the background concentration for ground water of such substance, except as provided in subsection (d) of this section.

(3) Remediation of a ground-water plume in a GB area shall also result in the reduction of each substance therein to a concentration such that such ground-water plume does not interfere with any existing use of the ground water.

(b) Surface-water protection criteria.

(1) Except as provided in subdivision (2) of this subsection, remediation of a ground-water plume which discharges to a surface water body shall result in the reduction of each substance therein to a concentration which is consistent with subdivision (2) of subsection (f) of this section and which is equal to or less than the surface-water protection criterion or an alternative surface-water protection criterion established in accordance with subdivision (3) of this subsection.

(2) If a ground-water plume (A) discharges to a wetland or an intermittent stream, or (B) the areal extent of such ground-water plume occupies more than 0.5%, or other percentage which is approved in writing by the Commissioner, of the upstream drainage basin of the stream to which such plume discharges measured from the intersection of stream and such ground-water plume, each substance therein shall be remediated to a concentration equal to or less than the applicable aquatic life criteria contained in Appendix D to the most recent Water Quality Standards, or equal to or less than an alternative water quality criterion adopted by the Commissioner in accordance with section 22a-426 of the General Statutes and paragraph 12b of the Water Quality Standards effective May 15, 1992.

(3) Alternative surface-water protection criteria.

Alternative surface-water criteria may be calculated in accordance with subparagraph (A) of this subdivision or may be approved in writing by the Commissioner in accordance with subparagraph (B) of this subdivision.

(A) An alternative surface-water protection criterion may be calculated for a substance in Appendix D of the most recent Water Quality Standards by multiplying the lower of the human health or aquatic life criterion for such substance in said Appendix D by $[(0.25 \times 7Q_{10})/Q_{\text{plume}}]$ where Q_{plume} is equal to the average daily discharge of polluted ground water from the subject ground-water plume.

(B) The Commissioner may approve an alternative surface-water protection criterion to be applied to a particular substance at a particular release area. Any person requesting such approval shall submit to the Commissioner: (i) a report on the flow rate, under seven day ten year low flow conditions, of the surface water body into which the subject ground water plume discharges (ii) a report on other surface water or ground water discharges to the surface water body within one-half mile upstream of the areal extent of the ground-water plume, (iii) a report on the instream water quality, (iv) a report on the flow rate of

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the ground-water discharge from such release area to the surface water body and the extent and degree of mixing of such discharge in such surface water, and (v) and any other information the Commissioner reasonably deems necessary to evaluate such request. The Commissioner shall not approve an alternative surface-water protection criterion under this subparagraph unless the requester demonstrates that such criterion will protect all existing and proposed uses of such surface water.

(c) Volatilization criteria.

(1) Except as specified in subdivisions (2), (3), (4) and (5) of this subsection, all ground water polluted with a volatile organic substance within 15 feet of the ground surface or a building, shall be remediated such that the concentration of each such substance is equal to or less than the applicable residential volatilization criterion for ground water.

(2) If ground water polluted with a volatile organic substance is below a building used solely for industrial or commercial activity, such ground water shall be remediated such that the concentration of such substance is equal to or less than the applicable industrial/commercial volatilization criterion for ground water, provided that an environmental land use restriction is in effect with respect to the parcel or portion thereof upon which such building is located, which restriction ensures that the parcel or portion thereof will not be used for any residential purpose in the future and that any future use of the parcel or portion thereof is limited to industrial or commercial activity;

(3) (A) Remediation of a volatile organic substance to the volatilization criterion for ground water shall not be required if the concentration of such substance in soil vapors below a building is equal to or less than (i) the residential volatilization criterion for soil vapor or (ii) the industrial/commercial volatilization criterion for soil vapor, if such building is solely used for industrial or commercial activity and, an environmental land use restriction is in effect with respect to the parcel or portion thereof upon which such building is located, which restriction ensures that the parcel or portion thereof will not be used for any residential purpose in the future and that any future use of the parcel or portion thereof is limited to industrial or commercial activity.

(B) The requirements of subdivision (1), (2), and (3) of this subsection do not apply if: (i) measures acceptable to the Commissioner have been taken to prevent the migration of such substance into any overlying building, (ii) a program is implemented to maintain and monitor all such measures, and (iii) notice of such measures has been submitted to the Commissioner on a form furnished by him which notice includes (aa) a brief description of the areal extent of the ground-water plume and of the area which exceeds any such volatilization or soil vapor criterion; (bb) a brief description of the method of controlling the migration of such substance into any overlying building; (cc) a plan for the monitoring and maintenance of such control method; and (dd) a map showing all existing buildings, the areal extent of the ground-water plume, and the location of such control method.

(4) Site-specific and alternative volatilization criteria.

(A) Site-specific residential volatilization criteria for ground water or soil vapor may be calculated using the equations in Appendix G to sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies.

(B) The Commissioner may approve an alternative volatilization criterion for ground water or for soil vapor to be applied to a substance at a particular release area. The Commissioner shall not approve any alternative criterion under this subparagraph unless it has been demonstrated that such criterion will ensure that volatile organic substances from such ground water or soil do not accumulate in the air of any structure used for residential activities at a concentration which, (i) for any carcinogenic substance creates a risk to human health in excess of a 10^{-6} excess lifetime cancer risk level, and for any non-carcinogenic substance does not exceed a hazard index of 1, or (ii) for a ground-water

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plume polluted with multiple volatile organic substances does not exceed a cumulative excess cancer risk level of 10^{-5} for carcinogenic substances, and for non-carcinogenic substances with the same target organ, the cumulative hazard index does not exceed 1.

(5) Exemption from volatilization criteria.

(A) The volatilization criteria do not apply to ground water polluted with volatile organic substances, where the water table is less than fifteen feet below the ground surface, if no building exists over the ground water polluted with volatile organic substances at a concentration above the applicable volatilization criteria, and (i) it has been documented that best efforts have been made to ensure that each owner of any parcel of land or portion thereof overlying such polluted ground water records an environmental land use restriction which ensures that no building is constructed over such polluted ground water; or (ii) the Commissioner has approved in writing a request demonstrating that no building can reasonably be expected to be constructed over the subject ground water or that natural attenuation or other methods of remediation will, within five years, reduce the concentration of volatile organic substances in such ground water to a concentration equal to or less than the applicable volatilization criteria.

(B) The volatilization criteria for ground water underlying an existing building do not apply to ground water polluted with volatile organic substances where the Commissioner has approved in writing and there have been implemented an indoor air monitoring program and measures to control the level of any such volatile organic substances in the air of the subject building.

(i) Any person seeking the Commissioner's approval of an indoor air monitoring program shall submit to him: a detailed written plan describing the proposed indoor air monitoring program, including but not limited to a description of the distribution and concentration of volatile organic compounds beneath the building, the location of proposed monitoring points, the proposed frequency of monitoring, the parameters to be monitored, and a description of proposed actions to be taken in the event such monitoring indicates that the monitored parameters exceed proposed specified concentrations and a proposed schedule for reporting to the Commissioner on the results of such monitoring for as long as monitoring is conducted at the site.

(ii) In approving any indoor air monitoring program pursuant to this subdivision, the Commissioner may impose any additional conditions he deems necessary to ensure that the program adequately protects human health. In the event that the Commissioner approves an indoor air monitoring program pursuant to this subparagraph, any person implementing such program shall perform all actions specified in the approved plan, and any additional measures specified by the Commissioner in his approval of such plan.

(d) Applicability of Ground-water Protection Criteria.

(1) Ground water in a GA area may be remediated to a concentration for each substance therein equal to or less than the ground-water protection criterion for each such substance if, with respect to the subject ground-water plume: (A) the background concentration for ground water is equal to or less than such ground-water protection criterion; (B) a public water supply distribution system is available within 200 feet of the subject parcel, parcels adjacent thereto, and any parcel within the areal extent of such plume; (C) such ground-water plume is not located in an aquifer protection area; and (D) such ground-water plume is not located within the area of influence of any public water supply well.

(2) If prior to any ground-water remediation the maximum concentration of a substance in a ground-water plume in a GA area is equal to or less than the ground-water protection criteria, remediation of ground water to achieve background ground-water concentration is not required,

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provided that the extent of the ground-water plume is not increasing over time and, except for seasonal variations, the concentration of the subject substance in such ground-water plume is not increasing at any point over time.

(3) Any ground water in a GB area and which is used for drinking or other domestic purposes shall be remediated to reduce the concentration of each substance therein to a concentration equal to or less than the applicable ground-water protection criterion until such time as the use of such ground water for drinking or other domestic purposes is permanently discontinued.

(e) Technical Impracticability of Ground-water Remediation.

(1) Exemption from Background Due to Technical Impracticability

If remediation of a ground-water plume in a GA area to achieve compliance with subdivision (2) of subsection (a) of this section has reduced the concentration of a polluting substance to less than the ground-water protection criterion, and if further reduction of such concentration is technically impracticable, no further remediation of such ground-water plume for such substance shall be required.

(2) Variance Due to Technical Impracticability of Ground-water Remediation

The Commissioner may grant a variance from any of the requirements of this section if he finds that: non-aqueous phase liquids that cannot be contained or removed in accordance with R.C.S.A. section 22a-133k-2(g) are present; remediation to the extent technically practicable has reduced the concentration of pollutants in ground water to steady-state concentrations that exceed any applicable criteria; or achieving compliance with the applicable criteria is technically impracticable as determined using Directive No. 9234.2-25 issued September 1993 by the U.S. Environmental Protection Agency's Office of Solid Waste and Emergency Response.

(A) Any person requesting a variance pursuant to this subsection from any ground-water protection criterion shall submit: (i) information concerning the concentration of each substance in the ground-water plume with respect to which a variance is sought; (ii) information demonstrating that (aa) the extent of the ground-water plume which exceeds such ground-water protection criterion has been reduced to the extent technically practicable, or (bb) it is not technically practicable to reduce the extent of the ground-water plume; (iii) the results of a study conducted to determine the risks to human health posed by the polluted ground water remaining after such reduction; (iv) if such study shows a risk or a potential risk to human health, a plan to eliminate such risk or potential risk; (v) an application to change the ground-water classification of such polluted ground water to GB in accordance with section 22a-426 of the General Statutes; and (vi) any other information the Commissioner reasonably deems necessary to evaluate such request.

(B) Any person requesting a variance pursuant to this subsection from the requirement to remediate ground water to a concentration which does not exceed the applicable surface-water protection criteria shall submit information concerning the concentration of each substance in the ground-water plume with respect to which a variance is sought. If such information demonstrates that any such concentration exceeds any applicable surface-water protection criterion, such person shall also submit: (i) a map showing the areal extent of the ground-water plume that exceeds such surface-water protection criterion, and (ii) a plan for controlling the migration of such substance to the receiving surface water body.

(C) If the Commissioner grants a variance pursuant to this subsection from any ground-water protection criterion, the person receiving the variance shall, no later than thirty days after the date of granting of such variance, submit to the Commissioner on a form prescribed and provided by him: (i) certification that written notice of the extent and degree of such pollution has been provided to each owner of property overlying the subject ground-water plume at which it is not technically practicable to remediate a substance to a concentration equal to or less than the ground-water protection criterion; (ii) certification

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that written notice of the presence of pollution on each such parcel and a description of the extent and degree of such pollution has been sent to the Director of Health of the municipality or municipalities in which the ground-water plume is located; and (iii) certification that best efforts have been made to ensure that each owner of property overlying the subject ground-water plume records an environmental land use restriction which ensures that the subject ground-water plume is not used for drinking or other domestic purposes;

(D) If the Commissioner grants a variance pursuant to this subsection from the requirement to remediate ground water to a concentration which does not exceed the applicable surface-water protection criteria, the person receiving the variance shall perform all actions specified in the plan submitted with the request for such variance, and any additional actions required by the Commissioner in his approval of such plan or granting of such variance.

(f) Applying the Criteria for Ground Water

(1) Compliance with the ground-water protection criterion for a substance in ground water or background concentration for ground water for such substance is achieved when the sampling locations are representative of the subject ground-water plume and (A) the analytical results for such substance at such all sampling locations are equal to or less than either the ground-water protection criterion for such substance or the background concentration for ground water therefor, whichever is applicable, for at least four consecutive quarterly sampling periods, or (B) a representative sampling program consisting of not less than twelve consecutive monthly samples from each such sampling location has been used to characterize the ground-water plume and the ninety-five percent upper confidence level of the arithmetic mean of all results of laboratory analyses of such samples for such substance are equal to or less than the criterion for such substance and that no single sample exceeds two times the applicable criterion for such substance.

(2) Compliance with a surface-water protection criterion for a substance in ground water is achieved when the sampling locations are representative of the subject ground-water plume and (A) the average concentration of such substance in such plume is equal to or less than the applicable surface-water protection criterion for at least four consecutive quarterly sampling periods, or (B) the concentration of such substance in that portion of such plume which is immediately upgradient of the point at which such ground-water discharges to the receiving surface-water body is equal to or less than the applicable surface-water protection criterion, provided that the areal extent of such ground-water plume is not increasing over time and that, except for seasonal variations, the concentration of the subject substance in such ground-water plume is not increasing, except as a result of natural attenuation, at any point over time.

(3) Compliance with a volatilization criterion for a substance in ground water or soil vapor is achieved when the sampling locations are representative of the subject ground-water plume or soil vapor and (A) the ninety-five percent upper confidence level of the arithmetic mean of all sample results from such locations is equal to or less than the applicable volatilization criterion for at least four consecutive quarterly sampling periods and that the result of no single sample exceeds two times the applicable volatilization criterion, or (B) the results of all laboratory analyses of samples for such substance are equal to or less than the volatilization criterion therefor.

(4) Matrix interference effects.

If any applicable criterion for a substance in ground water is less than the concentration for such substance that can be consistently and accurately quantified in a specific sample due to matrix interference effects, the following action shall be taken:

- (A) (i) "Test Methods for Evaluating Solid Waste : Physical/Chemical Methods," SW-846, U.S. Environmental Protection Agency, Office of Solid Waste, Washington D.C. 20460 shall be consulted to determine if an analytical method sufficiently sensitive to achieve the applicable analytical detection limit was used to conduct the

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analysis of the subject substance. If there is available an alternative analytical method which is sufficient to achieve the required analytical detection limit, appropriate for the sample matrix, and has been approved by EPA or approved in writing by the Commissioner, the subject ground water shall be re-analyzed for the subject substance using such alternative method.

(ii) If a sample has been analyzed by one or more analytical methods in accordance with subparagraph (A)(i) of this subdivision and the applicable analytical detection limit has not been achieved due to matrix interference effects, such method(s) shall be modified in order to compensate for such interferences, in accordance with analytical procedures specified by EPA within the scope of the analytical method.

- (B) If, after re-analyzing the subject ground water and attempting to compensate for matrix interference effects in accordance with subparagraph (A) of this subdivision, any applicable criterion for a substance in ground water is less than the concentration for such substance that can be consistently and accurately quantified in a specific sample due to matrix interference effects, compliance with such criterion shall be achieved when such ground water has been remediated to the lowest concentration for such substance which can be consistently and accurately quantified without matrix interference effects.
- (C) A detailed summary of all measures taken to overcome matrix interference effects and a determination of the lowest alternative quantification level applicable to the analysis of such substance shall be prepared and, if requested by the Commissioner in writing, shall be submitted to the Commissioner for his review and approval.

(g) Ground-water Monitoring.

For any remediation which is conducted to achieve compliance with sections 22a-133k-1 through 22a-133k-3, inclusive, of the Regulations of Connecticut State Agencies, ground-water monitoring shall be conducted in accordance with this subsection.

(1) Ground-water Monitoring at GA Areas.

With respect to remediation of a release area or a ground-water plume in a GA area, a ground-water monitoring plan shall be prepared and implemented. Ground-water monitoring under such plan shall be designed to determine:

- (A) the effectiveness of soil remediation in preventing the pollution of ground water by substances from the release area;
- (B) the effectiveness of any remediation taken to eliminate or minimize health or safety risks identified in any risk assessment conducted in accordance with subdivision (2) of subsection (e) of this section or otherwise identified; and
- (C) whether applicable requirements identified in subsection (a) of this section have been met.

(2) Ground-water Monitoring at GB Areas.

With respect to remediation of a release area or a ground-water plume in a GB area, a ground-water monitoring plan shall be prepared and implemented. Ground-water monitoring under such plan shall be designed to determine:

- (A) the effectiveness of soil remediation in preventing further pollution of ground water by substances from the release area;
- (B) the effectiveness of any remediation taken to eliminate or minimize identified health or safety risks associated with such release;
- (C) whether applicable ground-water protection criteria, surface-water protection criteria, and volatilization criteria have been met; and
- (D) whether the ground-water plume interferes with any existing use of the ground water

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for a drinking water supply or with any other existing use of the ground water, including but not limited to industrial, agricultural or commercial purposes.

(3) Discontinuation of Ground-water Monitoring.

(A) Unless otherwise specified in writing by the Commissioner, ground-water monitoring in a GA area may be discontinued in accordance with the following:

(i) a minimum of one year after compliance with the background concentration for ground water has been achieved in accordance with subsection (f) of this section if the background concentration for ground water of all substances in the subject ground-water plume has been maintained in all sampling events and ground-water monitoring data demonstrate that the soil remediation was effective in preventing the pollution of ground water by any substance from the subject release area; or

(ii) a minimum of three years after compliance with the ground-water protection criteria has been achieved in accordance with subsection (f) of this section if (aa) all applicable ground-water protection criteria for all subject substances or the background concentration for ground water for all substances in the subject ground-water plume, whichever is higher, is maintained in all sampling events; (bb) ground-water monitoring data demonstrate that the soil remediation was effective in preventing the pollution of ground water by substances from the subject release area; and (cc) the volatilization and surface-water protection criteria have been met in accordance with subsection (f) of this section.

(B) Unless otherwise specified in writing by the Commissioner, ground-water monitoring in a GB area may be discontinued two years after the cessation of all remediation of such ground water or soil if the applicable surface-water protection and volatilization criteria have been met in accordance with subsection (f) of this section, and such ground water is suitable for all existing uses.

(h) Additional Polluting Substances

(1) With respect to a substance in ground water for which a ground-water protection criterion is not specified in sections 22a-133k-1 through 22a-133k-3, inclusive, of the Regulations of Connecticut State Agencies, the Commissioner may approve in writing a ground-water protection criterion to apply to such substance. Any person requesting approval of a ground-water protection criterion for such substance shall submit to the commissioner (A) a risk-based ground-water protection criterion for such substance calculated in accordance with subdivision (2) of this subsection, (B) the analytical detection limit for such substance, (C) a description of the organoleptic properties of such substance. Before approving a ground-water protection criterion the Commissioner shall consider the proposed risk-based ground-water protection criterion for such substance, the analytical detection limit for such substance, the organoleptic effects of such substance, any information about the health effects such substance may cause due to exposure pathways not accounted for in the proposed risk-based ground-water protection criterion, and any other information that the Commissioner reasonably deems necessary.

(2) The risk-based ground-water protection criterion shall be calculated using the following equations:

(A) For carcinogenic substances;

$$GWPC = \left[\frac{\text{Risk}}{\text{CSF}} \right] \times \left[\frac{\text{BW} \times \text{AT}}{\text{IR} \times \text{EF} \times \text{ED} \times \text{CF}} \right]$$

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(B) For non-carcinogenic substances:

$$GWPC = \left[Rfd \times HI \right] \times \left[\frac{BW \times AT}{IR \times EF \times ED \times CF \times SA} \right]$$

(C) The abbreviations used in subparagraphs (A) and (B) of this subdivision shall be interpreted in accordance with the following table and shall be assigned the values specified therein:

Term	Description	Units	Value
GWPC _{RB}	Risk-based Ground-water protection Criterion	ug/l	calculated
Risk	Target Cancer Risk Level	unitless	1.0E-06
HI	Hazard Index	unitless	1.0
CSF	Cancer slope Factor	(mg/kg-day) ⁻¹	substance-specific
RFD	Reference Dose	mg/kg-day	substance-specific
IR	Ingestion Rate	l/day	2
EF	Exposure Frequency	days/year	365
ED	Exposure Duration	years	70
CF	Conversion Factor	unitless	1000
BW	Body Weight	kg	70
AT	Averaging Time,	days	25550
SA	Source Allocation	unitless	0.2

(i) Additional Remediation of Ground Water.

Nothing in sections 22a-133k-1 through 22a-133k-3, inclusive, of the Regulations of Connecticut State Agencies shall preclude the Commissioner from taking any action necessary to prevent or abate pollution, or to prevent or abate any threat to human health or the environment. If the presence of any substance impairs the aesthetic quality of any ground water which is or can reasonably be expected to be a source of water for drinking or other domestic use, additional remediation shall be conducted in order to reduce the concentration of such substance to a concentration appropriate for such use.

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Appendix A to
 Sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies
 Direct Exposure Criteria for Soil

Substance	Residential Criteria in mg/kg (ppm)	Industrial/ Commercial Criteria in mg/kg (ppm)
Volatile Organic Substances		
Acetone	500	1000
Acrylonitrile	1.1	11
Benzene	21	200
Bromoform	78	720
2-Butanone(MEK)	500	1000
Carbon tetrachloride	4.7	44
Chlorobenzene	500	1000
Chloroform	100	940
Dibromochloromethane	7.3	68
1,2-Dichlorobenzene	500	1000
1,3-Dichlorobenzene	500	1000
1,4-Dichlorobenzene	26	240
1,1-Dichloroethane	500	1000
1,2-Dichloroethane	6.7	63
1,1-Dichloroethylene	1	9.5
cis-1,2-Dichloroethylene	500	1000
trans-1,2-Dichloroethylene	500	1000
1,2-Dichloropropane	9	84
1,3-Dichloropropene	3.4	32
Ethylbenzene	500	1000

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Substance	Residential Criteria in mg/kg (ppm)	Industrial/ Commercial Criteria in mg/kg (ppm)
Ethylene dibromide (EDB)	0.007	0.067
Methyl-tert-butyl-ether	500	1000
Methyl isobutyl ketone	500	1000
Methylene chloride	82	760
Styrene	500	1000
1,1,1,2-Tetrachloroethane	24	220
1,1,2,2-Tetrachloroethane	3.1	29
Tetrachloroethylene	12	110
Toluene	500	1000
1,1,1-Trichloroethane	500	1000
1,1,2-Trichloroethane	11	100
Trichloroethylene	56	520
Vinyl chloride	0.32	3
Xylenes	500	1000
Semivolatile Substances		
Acenaphthylene	1000	2500
Anthracene	1000	2500
Benzo(a)anthracene	1	7.8
Benzo(b)fluoranthene	1	7.8
Benzo(k)fluoranthene	8.4	78
Benzo(a)pyrene	1	1

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Substance	Residential Criteria in mg/kg (ppm)	Industrial/ Commercial Criteria in mg/kg (ppm)
Bis(2-chloroethyl)ether	1	5.2
Bis(2-chloroisopropyl) ether	8.8	82
Bis(2-ethyl hexyl) phthalate	44	410
Butyl benzl phthalate	1000	2500
2-chlorophenol	340	2500
Di-n-butyl phthalate	1000	2500
Di-n-octyl phthalate	1000	2500
2,4-Dichlorophenol	200	2500
Fluoranthene	1000	2500
Fluorene	1000	2500
Hexachloroethane	44	410
Hexachlorobenzene	1	3.6
Naphthalene	1000	2500
Pentachlorophenol	5.1	48
Phenanthrene	1000	2500
Phenol	1000	2500
Pyrene	1000	2500
Inorganic Substances		
Antimony	27	8200
Arsenic	10	10
Barium	4700	140000

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Substance	Residential Criteria in mg/kg (ppm)	Industrial/ Commercial in mg/kg (ppm)
Beryllium	2	2
Cadmium	34	1000
Chromium, trivalent	3900	51000
Chromium, hexavalent	100	100
Copper	2500	76000
Cyanide	1400	41000
Lead	500	1000
Mercury	20	610
Nickel	1400	7500
Selenium	340	10000
Silver	340	10000
Thallium	5.4	160
Vanadium	470	14000
Zinc	20000	610000
Pesticides, PCB's, and Total Petroleum Hydrocarbons (TPH)		
Alachlor	7.7	72
Aldicarb	14	410
Atrazine	2.8	26
Chlordane	0.49	2.2
Dieldrin	0.038	0.36
Endrin	20	610
2-4 D	680	20000

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Substance	Residential Criteria in mg/kg (ppm)	Industrial/ Commercial in mg/kg (ppm)
Heptachlor epoxide	0.067	0.63
Heptachlor	0.14	1.3
Lindane	20	610
Methoxychlor	340	10000
Toxaphene	0.56	5.2
PCB's	1	10
TPH	500	2500

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Appendix B to
Sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies
Pollutant Mobility Criteria for Soil

Substance	GA, GAA Mobility Criteria in mg/kg (ppm)	GB Mobility Criteria in mg/kg (ppm)
Volatile Organic Substances		
Acetone	14	140
Acrylonitrile	0.01	0.1
Benzene	0.02	0.2
Bromoform	0.08	0.8
2-Butanone(MEK)	8	80
Carbon tetrachloride	0.1	1
Chlorobenzene	2	20
Chloroform	0.12	1.2
Dibromochloromethane	0.01	0.1
1,2-Dichlorobenzene	3.1	3.1
1,3-Dichlorobenzene	12	120
1,4-Dichlorobenzene	1.5	15
1,1-Dichloroethane	1.4	14
1,2-Dichloroethane	0.02	0.2
1,1-Dichloroethylene	0.14	1.4
cis-1,2-Dichloroethylene	1.4	14
trans-1,2-Dichloroethylene	2	20
1,2-Dichloropropane	0.1	1.0
1,3-Dichloropropene	0.01	0.1
Ethyl benzene	10.1	10.1
Ethylene dibromide (EDB)	0.01	0.1
Methyl-tert-butyl-ether	2	20
Methyl isobutyl ketone	7	14
Methylene chloride	0.1	1.0
Styrene	2	20
1,1,1,2-Tetrachloroethane	0.02	0.2

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Substance	GA, GAA Mobility Criteria in mg/kg (ppm)	GB Mobility Criteria in mg/kg (ppm)
1,1,2,2-Tetrachloroethane	0.01	0.1
Tetrachloroethylene	0.1	1
Toluene	20	67
1,1,1-Trichloroethane	4	40
1,1,2-Trichloroethane	0.1	1
Trichloroethylene	0.1	1.0
Vinyl chloride	0.04	0.40
Xylenes	19.5	19.5
Semivolatile Substances		
Acenaphthylene	8.4	84
Anthracene	40	400
Benzo(a)anthracene	1	1
Benzo(b)fluoranthene	1	1
Benzo(k)fluoranthene	1	1
Benzo(a)pyrene	1	1
Bis(2-chloroethyl)ether	1	2.4
Bis(2-chloroisopropyl)ether	1	2.4
Bis(2-ethyl hexyl)phthalate	1	11
Butyl benzl phthalate	20	200
2-chlorophenol	1	7.2
Di-n-butyl phthalate	14	140
Di-n-octyl phthalate	2	20
2,4-Dichlorophenol	1	4
Fluoranthene	5.6	56
Fluorene	5.6	56
Hexachloroethane	1	1
Hexachlorobenzene	1	1
Naphthalene	5.6	56
Pentachlorophenol	1	1
Phenanthrene	4	40
Phenol	80	800
Pyrene	4	40

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Substance	GA, GAA Mobility Criteria in mg/kg (ppm)	GB Mobility Criteria in mg/kg (ppm)
Pesticides and TPH		
Alachlor	0.230	0.4
Aldicarb	1	1
Atrazine	0.2	0.2
Chlordane	0.066	0.066
Dieldrin	0.007	0.007
2-4 D	1.4	14
Heptachlor epoxide	0.02	0.02
Heptachlor	0.013	0.013
Lindane	0.02	0.04
Methoxychlor	0.8	8
Simazine	0.8	8
Toxaphene	0.33	0.6
Total Petroleum Hydrocarbon By EPA Method 418.1 or another EPA-approved method acceptable to the Commissioner	500	2500
Inorganic Substances and PCB		
	GA, GAA Mobility Criteria By TCLP or by SPLP in mg/l (ppm)	GB Mobility Criteria By TCLP or by SPLP in mg/l (ppm)
Antimony	0.006	0.06
Arsenic	0.05	0.5
Barium	1	10.0
Beryllium	0.004	0.04
Cadmium	0.005	0.05
Chromium, total	0.05	0.5
Copper	1.3	13
Cyanide (by SPLP only)	0.2	2
Lead	0.015	0.15
Mercury	0.002	0.02
Nickel	0.1	1.0
Selenium	0.05	0.5

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Substance	GA, GAA Mobility Criteria By TCLP or by SPLP in mg/l (ppm)	GB Mobility Criteria By TCLP or by SPLP in mg/l (ppm)
Silver	0.036	0.36
Thallium	0.005	0.05
Vanadium	0.05	0.50
Zinc	5	50
PCB	0.0005	0.005

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Appendix C to
 Sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies
 Ground-Water Protection Criteria for GA and GAA Areas

Substance	Ground-water Protection Criteria in ug/l (ppb)
Volatile Organic Substances	
Acetone	700
Acrylonitrile	0.5
Benzene	1
Bromoform	4
2-Butanone(MEK)	400
Carbon tetrachloride	5
Chlorobenzene	100
Chloroform	6
Dibromochloromethane	0.5
1,2-Dichlorobenzene	600
1,3-Dichlorobenzene	600
1,4-Dichlorobenzene	75
1,1-Dichloroethane	70
1,2-Dichloroethane	1
1,1-Dichloroethylene	7
cis-1,2-Dichloroethylene	70
trans-1,2-Dichloroethylene	100
1,2-Dichloropropane	5
1,3-Dichloropropene	0.5
Ethyl benzene	700
Ethylene dibromide (EDB)	0.05
Methyl-tert-butyl-ether	100
Methyl isobutyl ketone	350
Methylene chloride	5
Styrene	100
1,1,1,2-Tetrachloroethane	1
1,1,2,2-Tetrachloroethane	0.5
Tetrachloroethylene	5

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Substance	Ground-water Protection Criteria in ug/l (ppb)
Toluene	1000
1,1,1-Trichloroethane	200
1,1,2-Trichloroethane	5
Trichloroethylene	5
Vinyl chloride	2
Xylenes	530
Semivolatile Substances	
Acenaphthylene	420
Anthracene	2000
Benzo(a)anthracene	0.06
Benzo(b)fluoranthene	0.08
Benzo(k)fluoranthene	0.5
Benzo(a)pyrene	0.2
Bis(2-chloroethyl)ether	12
Bis(2-chloroisopropyl)ether	12
Bis(2-ethyl hexyl)phthalate	2
Butyl benzl phthalate	1000
2-chlorophenol	36
Di-n-butyl phthalate	700
Di-n-octyl phthalate	100
2,4-Dichlorophenol	20
Fluoranthene	280
Fluorene	280
Hexachloroethane	3
Hexachlorobenzene	1
Naphthalene	280
Pentachlorophenol	1
Phenanthrene	200
Phenol	4000
Pyrene	200

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Substance	Ground-water Protection Criteria in ug/l (ppb)
Inorganic Substances	
Antimony	6
Arsenic	50
Asbestos in mfl	7 (mfl)
Barium	1000
Beryllium	4
Cadmium	5
Chromium (total)	50
Copper	1300
Cyanide	200
Lead	15
Mercury	2
Nickel	100
Selenium	50
Silver	36
Thallium	5
Vanadium	50
Zinc	5000
Pesticides, PCB and Total Petroleum Hydrocarbons	
Alachlor	2
Aldicarb	3
Atrazine	3
Chlordane	0.3
Dieldrin	0.002
2-4 D	70
Heptachlor epoxide	0.2
Heptachlor	0.4
Lindane	0.2
Methoxychlor	40
Simazine	4
Toxaphene	3

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Substance	Ground-water Protection Criteria in ug/l (ppb)
PCB's	0.5
Total Petroleum Hydrocarbon By EPA Method 418.1 or another EPA-approved method acceptable to the Commissioner	500

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Appendix D to
 Sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies
 Surface-water Protection Criteria
 for Substances in Ground Water

Substance	Surface-Water Protection Criteria in ug/l (ppb)
Volatile Organic Substances	
Acrylonitrile	20
Benzene	710
Bromoform	10800
Carbon tetrachloride	132
Chlorobenzene	420000
Chloroform	14100
Dibromochloromethane	1020
1,2-Dichlorobenzene	170000
1,3-Dichlorobenzene	26000
1,4-Dichlorobenzene	26000
1,2-Dichloroethane	2970
1,1-Dichloroethylene	96
1,3-Dichloropropene	34000
Ethylbenzene	580000
Methylene chloride	48000
1,1,2,2-Tetrachloroethane	110
Tetrachloroethylene	88
Toluene	4000000
1,1,1-Trichloroethane	62000
1,1,2-Trichloroethane	1260
Trichloroethylene	2340
Vinyl chloride	15750
Semivolatile Substances	
Acenaphthylene	0.3
Anthracene	1100000
Benzo(a)anthracene	0.3
Benzo(b)fluoranthene	0.3
Benzo(k)fluoranthene	0.3

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Substance	Surface-Water Protection Criteria in ug/l (ppb)
Benzo(a)pyrene	0.3
Bis(2-chloroethyl) ether	42
Bis(2-chloroisopropyl) ether	3400000
Bis(2-ethyl hexyl)phthalate	59
Di-n-butyl phthalate	120000
2,4-Dichlorophenol	15800
Fluoranthene	3700
Fluorene	140000
Hexachloroethane	89
Hexachlorobenzene	0.077
Phenanthrene	0.077
Phenol	92000000
Pyrene	110000
Inorganic Substances	
Antimony	86000
Arsenic	4
Asbestos (in mfl)	7 mfl
Beryllium	4
Cadmium	6
Chromium, trivalent	1200
Chromium, hexavalent	110
Copper	48
Cyanide	52
Lead	13
Mercury	0.4
Nickel	880
Selenium	50
Silver	12
Thallium	63
Zinc	123

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Substance	Surface-Water Protection Criteria In ug/l (ppb)
Pesticides and PCB	
Chlordane	0.3
Dieldrin	0.1
Endrin	0.1
Heptachlor epoxide	0.05
Heptachlor	0.05
Toxaphene	1
PCB's	0.5

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Appendix E to
Sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies
Volatilization Criteria for Ground Water

Volatle Substance	Residential Volatilization Criteria for Ground water in parts per billion	Industrial/Commercial Volatilization Criteria for Ground water in parts per billion
Acetone	50000	50000
Benzene	215	530
Bromoform	920	3800
2-Butanone (MEK)	50000	50000
Carbon Tetrachloride	16	40
Chlorobenzene	1800	6150
Chloroform	287	710
1,2-Dichlorobenzene	30500	50000
1,3-Dichlorobenzene	24200	50000
1,4-Dichlorobenzene	50000	50000
1,1-Dichloroethane	34600	50000
1,2-Dichloroethane	21	90
1,1-Dichloroethylene	1	6
1,2-Dichloropropane	14	60
1,3-Dichloropropene	6	25
Ethyl benzene	50000	50000
Ethylene dibromide (EDB)	4	16
Methyl-tert-butyl-ether	50000	50000
Methyl isobutyl ketone	50000	50000
Methylene chloride	50000	50000
Styrene	580	2065
1,1,1,2-Tetrachloroethane	12	50
1,1,2,2-Tetrachloroethane	23	100
Tetrachloroethylene	1500	3820
Toluene	23500	50000
1,1,1-Trichloroethane	20400	50000
1,1,2-Trichloroethane	8000	19600

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Volatile Substance	Residential Volatilization Criteria for Ground water in parts per billion	Industrial/Commercial Volatilization Criteria for Ground water in parts per billion
Trichloroethylene	219	540
Vinyl chloride	2	2
Xylenes	21300	50000

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Appendix F to
 Sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies
 Volatilization Criteria for Soil Vapor

Volatile Substance	Residential Volatilization Criteria for Soil Vapor in parts per million	Industrial/Commercial Volatilization Criteria for Soil Vapor in parts per million
Acetone	2400	8250
Benzene	1	113
Bromoform	1.5	6
2-Butanone (MEK)	2400	8285
Carbon Tetrachloride	1	2.7
Chlorobenzene	31	106
Chloroform	4.5	10.4
1,2-Dichlorobenzene	240	818
1,3-Dichlorobenzene	240	818
1,4-Dichlorobenzene	950	3270
1,1-Dichloroethane	850	3037
1,2-Dichloroethane	1	1
1,1-Dichloroethylene	1	1
1,2-Dichloropropane	1	1
1,3-Dichloropropene	1	1
Ethyl benzene	1650	5672
Ethylene dibromide (EDB)	1	1
Methyl-tert-butyl-ether	1000	3415
Methyl isobutyl ketone	140	480
Methylene chloride	1200	2907
Styrene	8	28
1,1,1,2-Tetrachloroethane	1	1.5
1,1,2,2- Tetrachloroethane	1	1
Tetrachloroethylene	11	27
Toluene	760	2615

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Volatile Substance	Residential Volatilization Criteria for Soil Vapor in parts per million	Industrial/Commercial Volatilization Criteria for Soil Vapor in parts per million
1,1,1-Trichloroethane	1310	4520
1,1,2-Trichloroethane	40	93
Trichloroethylene	7	16
Vinyl chloride	1	1
Xylenes	500	1702

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Appendix G to
Sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies
Equations, Terms and Values for Calculating Site-specific Volatilization Criteria
for Ground Water and Soil Vapor

Volatilization Criteria for Ground Water

Site-Specific Volatilization Criteria for Ground Water may be calculated using the following equations:

$$GWC = TAC / (1000 \cdot VF_{GW})$$

$$VF_{GW} = \frac{H[(D_{EFF-WS}/L_{GW})/(ER \cdot L_B)] \cdot 1000}{1 + [(D_{EFF-WS}/L_{GW})/(ER \cdot L_B)] + [(D_{EFF-WS}/L_{GW}) / ((D_{EFF-CRACK}/L_{CRACK}) \cdot \eta)]}$$

$$D_{EFF-WS} = (h_{CAP} + h_v) / [(h_{CAP} / D_{EFF-CAP}) + (h_v / D_{EFF-S})]$$

$$D_{EFF-CAP} = D_{AIR} \cdot (\theta_{ACAP}^{3.33} / \theta_T^2) + D_{WATER} / H \cdot (\theta_{WCAP}^{3.33} / \theta_T^2)$$

$$D_{EFF-S} = D_{AIR} \cdot (\theta_{AS}^{3.33} / \theta_T^2) + D_{WATER} / H \cdot (\theta_{WS}^{3.33} / \theta_T^2)$$

$$D_{EFF-CRACK} = D_{AIR} \cdot (\theta_{ACRACK}^{3.33} / \theta_T^2) + D_{WATER} / H \cdot (\theta_{WCRACK}^{3.33} / \theta_T^2)$$

Where:

Term	Description	Units	Value
GWC	Ground Water Volatilization Criteria	ug/kg	calculated
TAC	Target Indoor Air Concentration	ug/m ³	**
VF _{GW}	Ground Water Volatilization Factor	mg/m ³	calculated
H	Henry's Law Constant	unitless	substance-specific
D _{EFF-WS}	Effective Diffusion-Ground Water to Soil Surface	cm ² /s	calculated
L _{GW}	Depth to Ground Water (= h _{CAP} + h _v)	cm	site-specific
h _{CAP}	Thickness of Capillary Fringe	cm	site-specific
h _v	Thickness of Vadose Zone	cm	site-specific
ER _R	Residential Enclosed Space Air Exchange Rate	1/s	.00014
ER _I	Industrial Enclosed Space Air Exchange Rate	1/s	.00023

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Term	Description	Units	Value
L_{BR}	Residential Enclosed Space Volume/Infiltration Area Ratio	cm	site-specific
L_{BI}	Industrial Enclosed Space Volume/Infiltration Area Ratio	cm	site-specific
$D_{EFF-CRACK}$	Effective Diffusion through Foundation Cracks	cm^2/s	calculated
L_{CRACK}	Enclosed Space Foundation or Wall Thickness	cm	site-specific
η	Areal Fraction of Cracks in Foundations / Walls	unitless	.01
$D_{EFF-CAP}$	Effective Diffusion through Capillary Fringe	cm^2/s	calculated
D_{EFF-S}	Effective Diffusion through Soil (In Vapor Phase)	cm^2/s	calculated
D_{AIR}	Diffusion Coefficient in Air	cm^2/s	8.40E-02 or chemical specific
D_{WATER}	Diffusion Coefficient in Water	cm^2/s	1.00E-05 or chemical specific
θ_{ACAP}	Volumetric Air Content in Capillary Fringe	unitless	site-specific
θ_{AS}	Volumetric Air Content in Vadose Zone	unitless	site-specific
θ_{ACRACK}	Volumetric Air Content in Foundation/Wall Cracks	unitless	site-specific
θ_{WCAP}	Volumetric Water Content in Capillary Fringe	unitless	site-specific
θ_{WS}	Volumetric Water Content in Vadose Zone	unitless	site-specific
θ_{WCRACK}	Volumetric Water Content in Foundation/Wall Cracks	unitless	site-specific
θ_T	Total Soil Porosity	unitless	site-specific

**See attached "Table of Target Air Concentrations"

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Volatilization Criteria for Soil Vapor

Site-Specific Volatilization Criteria for Soil Vapor may be calculated using the following equations:

$$SSVC = TAC / (1000 \cdot VF_{SSV})$$

$$VF_{SSV} = \frac{[(D_{EFF-S}/L_S)/(ER \cdot L_B)]}{1 + [(D_{EFF-S}/L_S)/(ER \cdot L_B)] + [(D_{EFF-S}/L_S)/(D_{EFF-CRACK}/L_{CRACK}) \cdot \eta]}$$

$$D_{EFF-S} = D_{AIR} \cdot (\theta_{AS}^{3.33} / \theta_T^2) + D_{WATER}/H \cdot (\theta_{WS}^{3.33} / \theta_T^2)$$

$$D_{EFF-CRACK} = D_{AIR} \cdot (\theta_{ACRACK}^{3.33} / \theta_T^2) + D_{WATER}/H \cdot (\theta_{WCRACK}^{3.33} / \theta_T^2)$$

Where:

Terms	Description	Units	Value
SSVC	Volatilization Criteria for Soil Vapor	mg/m ³ -air	calculated
TAC	Target Indoor Air Concentration	ug/m ³ -air	**
VF _{SSV}	Volatilization Factor for Subsurface Vapors	unitless	calculated
H	Henry's Law Constant	unitless	substance-specific
D _{EFF-S}	Effective Diffusion through Soil (in Vapor Phase)	cm ² /s	calculated
L _S	Depth to Soil Vapor Sample	cm	site-specific
ER _R	Residential Enclosed Space Air Exchange Rate	1/s	.00014
ER _I	Industrial Enclosed Space Air Exchange Rate	1/s	.00023
L _{B-R}	Residential Enclosed Space Volume/Infiltration Area Ratio	cm	site-specific
L _{B-I}	Industrial Enclosed Space Volume/Infiltration Area Ratio	cm	site-specific
D _{EFF-CRACK}	Effective Diffusion through Foundation Cracks	cm ² /s	calculated
L _{CRACK}	Enclosed Space Foundation or Wall Thickness	cm	site-specific
η	Areal Fraction of Cracks in Foundations / Walls	unitless	calculated
θ _{AS}	Volumetric Air Content in Vadose Zone	unitless	site-specific
θ _{ACRACK}	Volumetric Air Content in Foundation/Wall Cracks	unitless	site-specific
θ _{WS}	Volumetric Water Content in Vadose Zone	unitless	site-specific
θ _{WCRACK}	Volumetric Water Content in Foundation/Wall Cracks	unitless	site-specific
θ _T	Total Soil Porosity	unitless	site-specific

** See attached "Table of Target Air Concentrations"

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Table of Target Air Concentrations

Volatle Substance	Residential Target Indoor Air Concentration in micrograms per cubic meter	Industrial/Commercial Target Indoor Air Concentration in micrograms per cubic meter
Acetone	8.34 E02	1.17 E03
Benzene	3.25 E00	2.15 E01
Bromoform	2.21 E00	3.72 E00
2-Butanone (MEK)	1.04 E03	1.46 E03
Carbon Tetrachloride	1.00 E00	1.00 E00
Chlorobenzene	2.09 E01	2.92 E01
Chloroform	3.00 E00	3.00 E00
1,2-Dichlorobenzene	2.09 E02	2.92 E02
1,3-Dichlorobenzene	2.09 E02	2.92 E02
1,4-Dichlorobenzene	8.34 E02	1.17 E03
1,1-Dichloroethane	5.21 E02	7.30 E02
1,2-Dichloroethane	9.36 E-02	1.57 E-01
1,1-Dichloroethylene	4.87 E-02	8.18 E-02
1,2-Dichloropropane	1.28 E-01	2.15 E-01
1,3-Dichloropropene	6.58 E-02	1.10 E-01
Ethyl benzene	1.04 E03	1.46 E03
Ethylene dibromide (EDB)	1.11 E-02	1.86 E-02
Methyl-tert-butyl-ether	5.21 E02	7.30 E02
Methyl isobutyl ketone	8.34 E01	1.17 E02
Methylene chloride	6.00 E02	6.00 E02
Styrene	5.00 E00	7.17 E00
1,1,1,2-Tetrachloroethane	3.29 E-01	5.52 E-01
1,1,2,2-Tetrachloroethane	4.20 E-02	7.05 E-02
Tetrachloroethylene	1.10 E01	1.10 E01
Toluene	4.17 E02	5.84 E02

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Volatile Substance	Residential Target Indoor Air Concentration in micrograms per cubic meter	Industrial/Commercial Target Indoor Air Concentration in micrograms per cubic meter
1,1,1-Trichloroethane	1.04 E03	1.46 E03
1,1,2-Trichloroethane	3.00 E01	3.00 E01
Trichloroethylene	5.00 E00	5.00 E00
Vinyl chloride	2.90 E-02	4.87 E-02
Xylenes	3.13 E02	4.38 E02

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Section 4. The Regulations of Connecticut State Agencies are amended by adding a new section 22a-133q-1 as follows:

22a-133q-1 Environmental land use restrictions

(a) Definitions.

For the purpose of this section, the definitions of the terms shall be the same as the definitions of terms in section 22a-133k-1 of the Regulations of Connecticut State Agencies. In addition, the following definitions shall apply:

"Class A-2 survey" means a first survey or independent re-survey which conforms to the "Recommended Standards for Surveys and Maps in the State of Connecticut Adopted on September 24, 1992, effective January 1, 1993 by the Connecticut Association of Land Surveyors, Inc." and which has been prepared by a land surveyor licensed in the State of Connecticut; complies with the minimum detail requirements for urban land title surveys adopted by the American Land Title Association and American Congress on Surveying and Maps (such requirements shall include all optional items on Table A thereof, exclusive of Items #1 (Monumentation), #5 (Contours in Elevation), #7b-2 (Other Data), and #12; and specifically shows (1) the boundaries of the Property by course and distance, together with the metes and bounds description corresponding to such survey; (2) the location of all improvements; (3) the location and width of all easements, utility lines, rights of way and building setback lines, with references to the book and page numbers for the instruments granting the same; (4) the location of all encroachments and restrictions, if any affecting the property; (5) the location of the portion of the parcel which is the subject of the proposed environmental land use restriction and (6) the latitude and longitude of the center of the subject property.

"Environmental land use restriction" means (1) a declaration of environmental land use restriction in the form set forth in Appendix 1 to section 22a-133q-1 of the Regulations of Connecticut State Agencies, or, in the case of an environmental land use restriction approved by a licensed environmental professional pursuant to P.A. 95-190, a declaration of environmental land use restriction in the form set forth in Appendix 2 to section 22a-133q-1 of the Regulations of Connecticut State Agencies; (2) a class A-2 survey of the subject parcel or portion thereof; (3) a certificate of title demonstrating that the subordination agreement(s) required under section 22a-133o of the General Statutes as amended by P.A. 95-190 has been recorded; and (4) a copy of the decision document prepared in accordance with subsection (f) of this section.

"Licensed environmental professional" means an environmental professional licensed in accordance with section 4 of P.A. 95-183.

(b) Applicability.

This section shall govern the execution and recording of environmental land use restrictions in accordance with section 22a-133n to 22a-133s, inclusive, of the General Statutes. Except as otherwise provided by section 22a-133o of the General Statutes, no environmental land use restriction shall be effective unless and until it has (1) been submitted to the Commissioner for his review and approved by him as evidenced by his signature on the original of the instrument setting forth such restriction; and (2) been recorded on the land records in the municipality in which the subject parcel is located.

(c) Publishing Notice of an Environmental Land Use Restriction.

(1) The owner of the parcel which is the subject of a proposed environmental land use restriction shall, except as specified in subdivision (1) of this subsection, publish in at least one newspaper of general circulation in the area affected by the proposed environmental land use restriction, notice of intent to record an environmental land use restriction. Such notice shall include the name and address of such owner, the address of the parcel or a brief description of its location, a brief description of the purpose of the proposed environmental land use restriction, the name and address of an individual from whom

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interested persons may obtain a copy of the proposed use restriction, and a statement that public comments on the proposed environmental land use restriction may be submitted in writing to the Commissioner of Environmental Protection, 79 Elm Street, Hartford, CT 06106 for thirty days after the date of publication of the notice.

(2) Notice of a proposed environmental land use restriction need not be published if (A) such restriction provides solely that the use of the subject parcel or portion thereof is restricted to industrial or commercial activities, and (B) the municipal zoning of such parcel limits the parcel to such use.

(d) Proposing an Environmental Land Use Restriction.

When submitting a proposed environmental land use restriction to the Commissioner for his review and approval, the owner of the affected parcel of land shall simultaneously submit:

- (1) a draft declaration of environmental land use restriction in the form set forth in Appendix 1 or 2 to section 22a-133q-1 of the Regulations of Connecticut State Agencies, as applicable;
- (2) a Class A-2 survey of the parcel or portion thereof which is the subject of the proposed environmental land use restriction;
- (3) a proposed decision document in accordance with subsection (f) of this section; and
- (4) a certified copy of the notice required by subsection (c) of this section, as such notice appeared in the newspaper or newspapers.

(e) Approval of an Environmental Land Use Restriction by the Commissioner.

After the close of the public comment period, the Commissioner shall decide whether to approve an environmental land use restriction. When making such decision the Commissioner shall consider: (1) all comments submitted; (2) whether such restriction will adequately protect human health and the environment from pollution at or emanating from the subject release area; and (3) whether such restriction conforms in all respects to the requirements of this section and sections 22a-133n through 22a-133s of the General Statutes.

(f) Decision Document.

Any environmental land use restriction approved pursuant to this section shall include a decision document prepared in accordance with this section. The decision document shall contain a detailed written description of:

- (1) the type and location of pollutants present in soil or ground water on or underlying the parcel or portion thereof which is the subject of the environmental land use restriction;
- (2) the provisions of the environmental land use restriction, including any limitations on the use of such parcel or portion thereof; and
- (3) description of the reason for the environmental land use restriction, including an explanation why such restriction is consistent with sections 22a-133k-1 through 22a-133k-3, inclusive, of the Regulations of Connecticut State Agencies.

The decision document shall also contain a summary of all comments on the proposed environmental land use restriction received following the publication of notice in accordance with subsection (c) of this section and a brief response to each comment. The decision document shall be signed by the Commissioner or, in the case of a restriction approved pursuant to P.A. 95-190, a licensed environmental professional to indicate approval of the decision document.

(g) Approval of an Environmental Land Use Restriction by a Licensed Environmental Professional.

When an environmental land use restriction is to be approved by a licensed environmental professional in accordance with P.A. 95-190, the licensed environmental professional shall review the documents listed in subsection (e), shall prepare a written approval of such restriction, and shall retain documentation of all documents reviewed by him. A licensed environmental professional shall not approve any environmental land use restriction unless it is consistent with sections 22a-133k-1 through 22a-133k-3, inclusive, of the Regulations of Connecticut State Agencies.

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(h) Subordination Agreements.

Whether the Commissioner or a licensed environmental professional approves an environmental land use restriction, prior to recording such environmental land use restriction on the municipal land records, the owner of the subject parcel shall submit to the Commissioner for his review and written approval: (1) copies of each subordination agreement, properly executed, required under section 22a-133o of the General Statutes; or (2) a certificate of title indicating that each person holding an interest in such parcel or any part thereof, including without limitation each mortgagee, lessee, lienor and encumbrancer, has irrevocably subordinated such interest to the environmental land use restriction.

(i) Recording an Environmental Land Use Restriction.

After the Commissioner or a licensed environmental professional, as applicable, has approved an environmental land use restriction in accordance with this section, the owner of the subject parcel shall record such restriction in accordance with this section and all other applicable law.

(j) Mailing Notice of an Environmental Land Use Restriction.

After an environmental land use restriction has been recorded, the owner of the subject parcel shall send, by certified mail, return receipt requested, a copy of such environmental land use restriction to (1) the chief administrative officer in the town where the parcel is located; (2) the chairman of the municipal planning, zoning or planning and zoning commission; (3) the local director of health; and (4) any person who submitted comments on such environmental use restriction.

(k) Release.

The owner of any parcel which is subject to an environmental land use restriction recorded in accordance with this section may request that the Commissioner release such parcel, in whole or in part, from the limitations of such restriction. If the Commissioner grants such request, the owner of such parcel shall, in accordance with law, record such release on the land records in the municipality where such parcel is located. No release of an environmental land use restriction shall be effective unless and until it has been submitted to the Commissioner for his review and approved by him as evidenced by his signature on the original of the instrument setting forth such release, and has been recorded on the land records of the municipality in which such parcel is located.

(l) Effect of Court Ruling on Environmental Land Use Restriction.

In the event that a court of competent jurisdiction rules that any portion of an environmental land use restriction recorded pursuant to this section is invalid, the owner of the subject parcel shall submit a copy of such restriction and such ruling to the Commissioner. The Commissioner shall review such restriction, and if he determines that such restriction would not have been approved without the invalid portion, he shall give notice that the environmental land use restriction is terminated as evidenced by his signature on an instrument setting forth such termination, and shall record such instrument on the land records of the municipality where such parcel is located. Promptly thereafter, the owner of the subject parcel shall take actions consistent with sections 22a-133k-1 through 22a-133k-3, inclusive, of the Regulations of Connecticut State Agencies to remediate the subject parcel or portion thereof. If the Commissioner determines in writing that the environmental land use restriction would have been approved without the invalid portion, the valid portion of the environmental land use restriction shall remain in full force and effect.

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Appendix 1 to
Section 22a-133q-1 of the Regulations of Connecticut State Agencies
Form of Environmental Land Use Restriction for Commissioner's Approval

Instructions: Any environmental land use restriction pursuant to R.C.S.A. section 22a-133q-1 shall be in the following form. The appropriate information shall be inserted in the blanks shown, and the appropriate language shall be selected from the choices shown in brackets, or if none of the choices addresses the specific circumstance, substitute language shall be inserted.

DECLARATION OF ENVIRONMENTAL LAND USE RESTRICTION
AND GRANT OF EASEMENT

This Declaration of environmental land use restriction and Grant of Easement is made this
day of , 1995, between ("the Grantor") and the Commissioner of Environmental
Protection of the State of Connecticut ("the Grantee").

W I T N E S S E T H:

WHEREAS, Grantor is the owner in fee simple of certain real property (the "Property") known as [Address/Location located in the Town of in County] [designated as Lot , Block on the tax map of the Town of in County], more particularly described on Exhibit A which is attached hereto and made a part hereof; and

WHEREAS, the Grantee has determined that the environmental land use restriction set forth below is consistent with regulations adopted by him pursuant to Section 22a-133k of the Connecticut General Statutes; and

WHEREAS, the Grantee has determined that this environmental land use restriction will effectively protect public health and the environment from the hazards of pollution; and

WHEREAS, the Grantee's written approval of this Environmental land use restriction is contained in the document attached hereto as Exhibit B (the "Decision Document") which is made a part hereof; and

WHEREAS, the property or portion thereof identified in the class A-2 survey ("the Subject Area") which survey is attached hereto as Exhibit C which is made a part hereof, contains pollutants and

WHEREAS, to prevent exposure to or migration of such pollutants and to abate hazards to human health and the environment, and in accordance with the Decision Document, the Grantor desires to impose certain restrictions upon the use, occupancy, and activities of and at the Subject Area, and to grant this environmental land use restriction to the Grantee on the terms and conditions set forth below; and

WHEREAS, Grantor intends that such restrictions shall run with the land and be binding upon and enforceable against Grantor and Grantor's successors and assigns;

NOW, THEREFORE, Grantor agrees as follows:

1. Purpose. In accordance with the Decision Document, the purpose of this Environmental land use restriction is to assure [that the Subject Area is not used for residential activities], [that ground water at the Subject Area is not utilized for drinking purposes], [that humans are not exposed to soils at the Subject Area polluted with substances in concentrations exceeding the direct exposure criteria established in R.C.S.A. sections 22a-133k-1 through 22a-133k-3, inclusive], [that water does not infiltrate soils at the Subject Area polluted with substances in concentrations exceeding the pollutant mobility criteria established in R.C.S.A. sections 22a-133k-1 through 22a-133k-3, inclusive] [that buildings are not constructed over soils or ground water at the Subject Area polluted with substances in concentrations exceeding the volatilization criteria established in R.C.S.A. sections 22a-133k-1 through 22a-133k-3,

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inclusive], [that the engineered control described in Exhibit D attached hereto is not disturbed and is properly maintained to prevent human exposure to soils at the Subject Area polluted with substances in concentrations exceeding the direct exposure criteria established in R.C.S.A. sections 22a-133k-1 through 22a-133k-3, inclusive, and/or that water does not infiltrate soils at the Subject Area polluted with substances in concentrations exceeding the pollutant mobility criteria established in R.C.S.A. sections 22a-133k-1 through 22a-133k-3, inclusive.]

2. Restrictions Applicable to the Subject Area: In furtherance of the purposes of this environmental land use restriction, Grantor shall assure that use, occupancy, and activity of and at the Subject Area are restricted as follows:

- [A. Use. No residential use of the Subject Area shall be permitted.
- B. Ground water. Ground water at the Subject Area shall not be used for drinking or other domestic purposes.
- C. Disturbances. Soil at the Subject Area shall not be disturbed in any manner, including without limitation,
- D. Construction. No building shall be constructed on the Subject Area.]

3. Except as provided in Paragraph 4 below, no action shall be taken, allowed, suffered, or omitted if such action or omission is reasonably likely to:

- i. Create a risk of migration of pollutants or a potential hazard to human health or the environment; or
- ii. Result in a disturbance of the structural integrity of any engineering controls designed or utilized at the Property to contain pollutants or limit human exposure to pollutants.

4. Emergencies. In the event of an emergency which presents a significant risk to human health or the environment, the application of Paragraph 3 above may be suspended, provided such risk cannot be abated without suspending such Paragraph and the Grantor:

- i. Immediately notifies the Grantee of the emergency;
- ii. Limits both the extent and duration of the suspension to the minimum reasonably necessary to adequately respond to the emergency;
- iii. Implements all measures necessary to limit actual and potential present and future risk to human health and the environment resulting from such suspension; and
- iv. Implements a plan approved in writing by the Grantee, on a schedule approved by the Grantee, to ensure that the Subject Area is remediated in accordance with R.C.S.A. sections 22a-133k-1 through 22a-133k-3, inclusive, or restored to its condition prior to such emergency.

5. Release of Restriction; Alterations of Subject Area. Grantor shall not make, or allow or suffer to be made, any alteration of any kind in, to, or about any portion of any of the Subject Area inconsistent with this Environmental land use restriction unless the Grantor has first recorded the Grantee's written approval of such alteration upon the land records of [name of municipality where Subject Area is located]. The Grantee shall not approve any such alteration and shall not release the Property from the provisions of this environmental land use restriction unless the Grantor demonstrates to the Grantee's satisfaction that Grantor has remediated the Subject Area in accordance with R.C.S.A. sections 22a-133k-1 through 22a-133k-3, inclusive.

6. Grant of Easement to the Grantee. Grantor hereby grants and conveys to the Grantee, his agents, contractors, and employees, and to any person performing pollution remediation activities under the direction thereof, a non-exclusive easement (the "Easement") over the Subject Area and over such other parts of the Property as are necessary for access to the Subject Area or for carrying out any actions to abate a threat to human health or the environment associated with the Subject Area. Pursuant to this Easement, the Grantee, his agents, contractors, and employees, and any person performing pollution remediation activities under the direction thereof, may enter upon and inspect the Property and perform such investigations and actions as the Grantee deems necessary for any one or more of the following purposes:

- i. Ensuring that use, occupancy, and activities of and at the Property are consistent with this

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environmental land use restriction;

ii. Ensuring that any remediation implemented complies with R.C.S.A. sections 22a-133k-1 through 22a-133k-3, inclusive;

iii. Performing any additional investigations or remediation necessary to protect human health and the environment;

[iv. Ensuring the structural integrity of any engineering controls described in this Environmental land use restriction and Grant of Easement and their continuing effectiveness in containing pollutants and limiting human exposure to pollutants.]

7. Notice and Time of Entry onto Property. Entry onto the Property by the Grantee pursuant to this Easement shall be upon reasonable notice and at reasonable times, provided that entry shall not be subject to these limitations if the Grantee determines that immediate entry is necessary to protect human health or the environment.

8. Notice to Lessees and Other Holders of Interests in the Property. Grantor, or any future holder of any interest in the property, shall cause any lease, grant, or other transfer of any interest in the Property to include a provision expressly requiring the lessee, grantee, or transferee to comply with this environmental land use restriction and Grant of Easement. The failure to include such provision shall not affect the validity or applicability to the Property of this environmental land use restriction and Grant of Easement.

9. Persons Entitled to Enforce Restrictions. The restrictions in this environmental land use restriction on use, occupancy, and activity of and at the Property shall be enforceable in accordance with section 22a-133p of the General Statutes.

10. Severability and Termination. If any court of competent jurisdiction determines that any provision of this environmental land use restriction or Grant of Easement is invalid or unenforceable, such provision shall be deemed to have been modified automatically to conform to the requirements for validity and enforceability as determined by such court. In the event that the provision invalidated is of such nature that it cannot be so modified, the provision shall be deemed deleted from this instrument as though it had never been included herein. In either case, the remaining provisions of this instrument shall remain in full force and effect. Further, in either case, the Grantor shall submit a copy of this restriction and of the judgement of the Court to the Grantee in accordance with R.C.S.A. section 22a-133q-1(1). This environmental land use restriction shall be terminated if the Grantee provides notification pursuant to R.C.S.A. section 22a-133q-1(l).

11. Binding Effect. All of the terms, covenants and conditions of this environmental land use restriction and grant of easement shall run with the land and shall be binding on the Grantor, the Grantor's successors and assigns, and each owner and any other party entitled to possession or use of the Property during such period of ownership or possession.

12. Terms Used Herein. The definitions of terms used herein shall be the same as the definitions contained in sections 22a-133k-1 and 22a-133o-1 of the Regulations of Connecticut State Agencies as such sections existed on the date of execution of this environmental land use restriction..

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Appendix 2 to
Section 22a-133q-1 of the Regulations of Connecticut State Agencies
Form of Environmental Land Use Restriction for Licensed Environmental Professional's Approval

Instructions: Any environmental land use restriction pursuant to R.C.S.A. section 22a-133q-1 shall be in the following form. The appropriate information shall be inserted in the blanks shown, and the appropriate language shall be selected from the choices shown in brackets, or if none of the choices addresses the specific circumstance, substitute language shall be inserted.

DECLARATION OF ENVIRONMENTAL LAND USE RESTRICTION
AND GRANT OF EASEMENT

This Declaration of environmental land use restriction and Grant of Easement is made this
day of , 1995, between ("the Grantor") and the Commissioner of Environmental
Protection of the State of Connecticut ("the Grantee").

W I T N E S S E T H:

WHEREAS, Grantor is the owner in fee simple of certain real property (the "Property") known as [Address/Location located in the Town of in County] [designated as Lot , Block on the tax map of the Town of in County], more particularly described on Exhibit A which is attached hereto and made a part hereof; and

WHEREAS, remediation of the Property has been conducted in accordance with Public Act 95-190; and

WHEREAS, the Licensed Environmental Professional whose signature appears below has determined that the environmental land use restriction set forth below is consistent with regulations adopted by the Commissioner of Environmental Protection pursuant to Section 22a-133k of the Connecticut General Statutes; and

WHEREAS, the Licensed Environmental Professional whose signature appears below has determined that this environmental land use restriction will effectively protect public health and the environment from the hazards of pollution; and

WHEREAS, the written approval of this Environmental land use restriction by the Licensed Environmental Professional whose signature appears below is contained in the document attached hereto as Exhibit B (the "Decision Document") which is made a part hereof; and

WHEREAS, the property or portion thereof identified in the class A-2 survey ("the Subject Area") which survey is attached hereto as Exhibit C which is made a part hereof, contains pollutants; and

WHEREAS, to prevent exposure to or migration of such pollutants and to abate hazards to human health and the environment, and in accordance with the Decision Document, the Grantor desires to impose certain restrictions upon the use, occupancy, and activities of and at the Subject Area, and to grant this environmental land use restriction to the Grantee on the terms and conditions set forth below; and

WHEREAS, Grantor intends that such restrictions shall run with the land and be binding upon and enforceable against Grantor and Grantor's successors and assigns;

NOW, THEREFORE, Grantor agrees as follows:

1. Purpose. In accordance with the Decision Document, the purpose of this Environmental land use restriction is to assure [that the Subject Area is not used for residential activities], [that ground

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water at the Subject Area is not utilized for drinking purposes], [that humans are not exposed to soils at the Subject Area polluted with substances in concentrations exceeding the direct exposure criteria established in R.C.S.A. sections 22a-133k-1 through 22a-133k-3, inclusive], [that water does not infiltrate soils at the Subject Area polluted with substances in concentrations exceeding the pollutant mobility criteria established in R.C.S.A. sections 22a-133k-1 through 22a-133k-3, inclusive] [that buildings are not constructed over soils or ground water at the Subject Area polluted with substances in concentrations exceeding the volatilization criteria established in R.C.S.A. sections 22a-133k-1 through 22a-133k-3, inclusive], [that the engineered control described in Exhibit D attached hereto is not disturbed and is properly maintained to prevent human exposure to soils at the Subject Area polluted with substances in concentrations exceeding the direct exposure criteria established in R.C.S.A. sections 22a-133k-1 through 22a-133k-3, inclusive, and/or that water does not infiltrate soils at the Subject Area polluted with substances in concentrations exceeding the pollutant mobility criteria established in R.C.S.A. sections 22a-133k-1 through 22a-133k-3, inclusive].

2. Restrictions Applicable to the Subject Area: In furtherance of the purposes of this environmental land use restriction, Grantor shall assure that use, occupancy, and activity of and at the Subject Area are restricted as follows:

- [A. Use. No residential use of the Subject Area shall be permitted.
- B. Ground water. Ground water at the Subject Area shall not be used for drinking or other domestic purposes.
- C. Disturbances. Soil at the Subject Area shall not be disturbed in any manner, including without limitation,
- D. Construction. No building shall be constructed on the Subject Area.]

3. Except as provided in Paragraph 4 below, no action shall be taken, allowed, suffered, or omitted if such action or omission is reasonably likely to:

- i. Cause migration of pollutants or create a potential hazard to human health or the environment; or
- ii. Result in a disturbance of the structural integrity of any engineering controls or other structures designed or utilized at the Property to contain pollutants or limit human exposure to pollutants.

4. Emergencies. In the event of an emergency which presents a significant risk to human health or the environment, the application of Paragraph 3 above may be suspended, provided such risk cannot be abated without suspending such Paragraph and the Grantor:

- i. Immediately notifies the Grantee of the emergency;
- ii. Limits both the extent and duration of the suspension to the minimum reasonably necessary to adequately respond to the emergency;
- iii. Implements all measures necessary to limit actual and potential present and future risk to human health and the environment resulting from such suspension; and
- iv. Implements a plan approved in writing by the Grantee, on a schedule approved by the Grantee, to ensure that the Subject Area is remediated in accordance with R.C.S.A. sections 22a-133k-1 through 22a-133k-3, inclusive, or restored to its condition prior to such emergency.

5. Release of Restriction; Alterations of Subject Area. Grantor shall not make, or allow or suffer to be made, any alteration of any kind in, to, or about any portion of any of the Subject Area inconsistent with this Environmental land use restriction unless the Grantor has first recorded the Grantee's written approval of such alteration upon the land records of [name of municipality where Subject Area is located]. The Grantee shall not approve any such alteration and shall not release the Property from the provisions of this environmental land use restriction unless the Grantor demonstrates to the Grantee's satisfaction that Grantor has remediated the Subject Area in accordance with R.C.S.A. sections 22a-133k-1 through 22a-133k-3, inclusive.

6. Grant of Easement to the Grantee. Grantor hereby grants and conveys to the Grantee, his agents, contractors, and employees, and to any person performing pollution remediation activities under the direction thereof, a non-exclusive easement (the "Easement") over the Subject Area and over such other parts of the Property as are necessary for access to the Subject Area or for carrying

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out any actions to abate a threat to human health or the environment associated with the Subject Area. Pursuant to this Easement, the Grantee, his agents, contractors, and employees, and any person performing pollution remediation activities under the direction thereof, may enter upon and inspect the Property and perform such investigations and actions as the Grantee deems necessary for any one or more of the following purposes:

- I. Ensuring that use, occupancy, and activities of and at the Property are consistent with this environmental land use restriction;
- ii. Ensuring that any remediation implemented complies with R.C.S.A. sections 22a-133k-1 through 22a-133k-3, inclusive;
- iii. Performing any additional investigations or remediation necessary to protect human health and the environment;
- [iv. Ensuring the structural integrity of any engineering controls described in this Environmental land use restriction and Grant of Easement and their continuing effectiveness in containing pollutants and limiting human exposure to pollutants.]

7. Notice and Time of Entry onto Property. Entry onto the Property by the Grantee pursuant to this Easement shall be upon reasonable notice and at reasonable times, provided that entry shall not be subject to these limitations if the Grantee determines that immediate entry is necessary to protect human health or the environment.

8. Notice to Lessees and Other Holders of Interests in the Property. Grantor, or any future holder of any interest in the property, shall cause any lease, grant, or other transfer of any interest in the Property to include a provision expressly requiring the lessee, grantee, or transferee to comply with this environmental land use restriction and Grant of Easement. The failure to include such provision shall not affect the validity or applicability to the Property of this environmental land use restriction and Grant of Easement.

9. Persons Entitled to Enforce Restrictions. The restrictions in this environmental land use restriction on use, occupancy, and activity of and at the Property shall be enforceable in accordance with section 22a-133p of the General Statutes.

10. Severability and Termination. If any court of competent jurisdiction determines that any provision of this environmental land use restriction or Grant of Easement is invalid or unenforceable, such provision shall be deemed to have been modified automatically to conform to the requirements for validity and enforceability as determined by such court. In the event that the provision invalidated is of such nature that it cannot be so modified, the provision shall be deemed deleted from this instrument as though it had never been included herein. In either case, the remaining provisions of this instrument shall remain in full force and effect. Further, in either case, the Grantor shall submit a copy of this restriction and of the judgement of the Court to the Grantee in accordance with R.C.S.A. section 22a-133q-1(1). This environmental land use restriction shall be terminated if the Grantee provides notification pursuant to R.C.S.A. section 22a-133q-1(l).

11. Binding Effect. All of the terms, covenants and conditions of this environmental land use restriction and grant of easement shall run with the land and shall be binding on the Grantor, the Grantor's successors and assigns, and each owner and any other party entitled to possession or use of the Property during such period of ownership or possession.

12. Terms Used Herein. The definitions of terms used herein shall be the same as the definitions contained in sections 22a-133k-1 and 22a-133o-1 of the Regulations of Connecticut State Agencies as such sections existed on the date of execution of this environmental land use restriction.

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Section 5. Section 22a-209-1 of the Regulations of Connecticut State Agencies is repealed and the following is substituted in lieu thereof:

Sec. 22a-209-1. Definitions

"AASHTO specification" means a standard of performance for buried structures set forth in "Standard Specifications for Transportation Materials," published by the American Association of State Highway and Transportation Officials in 1989, 14TH edition.

"All weather access" means that affected roads or land surface can support operation of vehicles for the transportation of solid waste and vehicles for the maintenance of solid waste facilities under all normal climatic conditions, provided that snow is removed and flooding is precluded.

"Alter" (1) when referring to a solid waste facility which has no permit, means to change the existing configuration or method of operation of the facility in any manner, including but not limited to adding to the volume of solid waste deposited at the facility; (2) when referring to a solid waste facility which holds a permit, means to change the approved configuration or method of operation of the facility in any manner, including but not limited to adding to the approved volume of solid waste deposited at the facility.

"Asbestos" means actinolite, amosite, antnophyllite, chrysotile, crocidolite, tremolite, or any material which contains the above, all or part of which is in a friable state.

"ASTM specification" means a standard for pipes or other construction materials set forth in "Annual Book of ASTM Standards," published by the American Society of Testing Materials in 1989.

"Base flood" means a flood that has a one percent or greater chance of recurring in any year or a flood of a magnitude equaled or exceeded once in 100 years on the average over a significantly long period. If the Commissioner deems it necessary for a particular location, the base flood shall represent a less common occurrence as specified by him or her.

"Bird hazard" means an increase in the likelihood of bird/aircraft collisions that may cause damage to the aircraft or injury to its occupants.

"Bulky waste" means landclearing debris and waste resulting directly from demolition activities other than clean fill.

"Cell construction method" means the spreading, compacting and daily covering of solid wastes through use of the area, ramp, or trench methods of landfilling.

"Certified operator" means the solid waste facility operator or an employee of the such operator who is present on site and oversees or carries out the daily operation of the facility, and whose qualifications are approved in accordance with Section 22a-209-6 of the Regulations of Connecticut State Agencies.

"Certified soil scientist" means a person who has been certified as a soil scientist by the Board of Directors of the Society of Soil Scientists of Southern New England.

"Clean fill" means (1) natural soil (2) rock, brick, ceramics, concrete, and asphalt paving fragments which are virtually inert and pose neither a pollution threat to ground or surface waters nor a fire hazard AND (3) POLLUTED SOIL AS DEFINED IN SUBDIVISION (45) OF SUBSECTION (a) OF SECTION 22a-133k-1 OF THE REGULATIONS OF CONNECTICUT STATE AGENCIES WHICH SOIL HAS BEEN TREATED TO REDUCE THE CONCENTRATION OF POLLUTANTS TO LEVELS WHICH DO NOT EXCEED THE APPLICABLE POLLUTANT MOBILITY CRITERIA AND DIRECT EXPOSURE CRITERIA ESTABLISHED IN SECTIONS 22a-133k-1 THROUGH 22a-133k-3 OF THE REGULATIONS OF CONNECTICUT STATE AGENCIES AND WHICH SOIL IS REUSED IN ACCORDANCE WITH R.C.S.A. SUBDIVISION (3) OF SUBSECTION (h) OF SECTION 22a-133k-2 OF SUCH REGULATIONS.

"Cover material" means soil, or other suitable material as approved by the Commissioner, which is used to cover compacted solid waste in a solid or special waste disposal area. Any soils used shall be classified as GM, silty gravels, poorly graded gravel-sand-silt mixtures; GC, clayey gravels, poorly graded gravel-sand-clay mixtures; SM, silty sands, poorly graded sand-silt mixtures; SC, clayey sands, poorly graded sand-clay mixtures; ML, inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity in accordance with the unified soil classification system.

"Dewater" means to subject material to a process that removes water.

"Dioxin sampling well" means a stainless steel ground water monitoring well installed within the area of predicted leachate plume from any portion of a solid waste facility at which residue is disposed.

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"Facility plan" means the engineering studies and proposals to build, establish, alter, operate, monitor and close a solid waste facility, required by Section 22a-209-4(b)(2) of the Regulations of Connecticut State Agencies.

"Floodplain" means the lowland and relatively flat areas adjoining inland and coastal waters, including flood-prone areas of offshore islands, which are inundated by the base flood.

"Friable" means readily crumbled, pulverized or reduced to powder, when dry, by hand pressure.

"Geotextile" means a woven or nonwoven fabric or film which is utilized for the engineering management of soil and water.

"Groundwater" means water present in the zone of saturation.

"Groundwater monitoring well" means a dug, driven or drilled well used to determine groundwater elevation, direction of groundwater flow, or the quality of groundwater.

"Hazardous Waste" means any waste material which may pose a present or potential hazard to human health or the environment when improperly treated, stored, transported or disposed of or otherwise managed, including hazardous waste identified in accordance with Section 3001 of the Resource Conservation and Recovery Act of 1976 (42 USC 6901 et seq.) as amended.

"Leachate" means that liquid which results from ground or surface water which has been in contact with solid waste and has extracted material, either dissolved or suspended, from the solid waste.

"Lift" means a horizontal layer of cells within a solid waste disposal area at which the cell construction method is utilized.

"Lower explosive limit" means the lowest percent by volume of gas which will propagate a flame in air at 25° C and atmospheric pressure.

"Maximum high water table" means the highest elevation reached by the upper level of the ground water as determined by an engineering evaluation conducted in accordance with test methods approved by the Commissioner.

"Monocell" means a variation of the cell construction method whereby only a single type of solid waste is disposed of in any individual cell.

"Mottling indicator" means a residual trace of reduced or oxidized iron left on soil strata as the result of fluctuations in groundwater elevation.

"Mulch" means a protective cover of organic material placed over soil to preserve soil moisture, prevent erosion, or promote the growth of plants.

"Municipal solid waste" means solid waste from residential, commercial, industrial and institutional sources, excluding solid waste consisting of significant quantities of hazardous waste as defined in Section 22a-115 of the General Statutes, landclearing debris, biomedical waste, sewage sludge and scrap metal.

"NATURAL SOIL" MEANS SOIL IN WHICH ALL SUBSTANCES NATURALLY OCCURRING THEREIN ARE PRESENT IN CONCENTRATIONS NOT EXCEEDING THE CONCENTRATIONS OF SUCH SUBSTANCE OCCURRING NATURALLY IN THE ENVIRONMENT AND IN WHICH SOIL NO OTHER SUBSTANCE IS ANALYTICALLY DETECTABLE. FOR THE PURPOSE OF THIS DEFINITION, SUBSTANCE SHALL HAVE THE SAME MEANING AS IN SECTION 22a-133k-1 OF THE REGULATIONS OF CONNECTICUT STATE AGENCIES.

"New municipal solid waste disposal area" means a solid waste facility or expansion thereof, other than a vertical expansion, for the disposal of municipal solid waste, for which facility or expansion a completed application under Sections 22a-430 and 22a-208a of the General Statutes is received by the Commissioner after the effective date of Section 22a-209-14 of the Regulations of Connecticut State Agencies.

"Open dump" means a site at which solid waste is disposed of in a manner which does not comply with Subtitle D of the Resource Conservation and Recovery Act of 1976, (42 USC 6901 et seq.), as amended, and regulations promulgated thereunder.

"Operator" means a person who is ultimately responsible for maintaining the solid waste facility in conformance with applicable statutes and regulations and the facility permits.

"Pan lysimeter" means a leachate collection device for sampling leachate from monocells within a solid waste disposal area.

"Person" means any individual, firm, partnership, association, syndicate, company, trust, corporation, municipality, agency or political or administrative subdivision of the state, or other legal entity of any kind.

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"Public airport" means an airport open to the public without prior permission and without restrictions within the physical capacities of available facilities.

"Recharge" means water which enters a geologic formation.

"Regional solid waste disposal area" means a solid waste disposal area used for the disposal of solid waste generated in more than one municipality.

"Residue" means bottom ash, air pollution control residue, and other residues from the combustion process at resource recovery facilities, municipal solid waste incinerators, and biomedical waste incinerators.

"Resources recovery facility" means a volume reduction plant, as defined by Section 22a-207 of the General Statutes as amended, utilizing processes aimed at reclaiming the material or energy values from solid wastes.

"Rip-rap" means a loose assemblage of broken or whole stones utilized to dissipate the velocity and energy of moving water.

"Scarification" means the process of raking, harrowing or otherwise disturbing a soil surface to allow infiltration of water or other material.

"Solid waste boundary" means the outermost perimeter of the solid or special waste (projected in the horizontal plane) as it would exist at completion of the permitted disposal activity at a solid waste or special waste disposal area.

"Special waste disposal area" means a solid waste disposal area at which special wastes, as defined in this section, are disposed of.

"Special wastes" means the following wastes, so long as they are not hazardous waste pursuant to section 22a-115 of the General Statutes or radioactive material subject to section 22a-148 of the General Statutes: (1) water treatment, sewage treatment or industrial sludges, liquid, solids and contained gases; fly-ash and casting sands or slag; and contaminated dredge spoils; (2) scrap tires; (3) bulky waste, as defined in this section; (4) asbestos; (5) residue; and (6) biomedical waste.

"Standard proctor density" means the maximum weight per unit volume of earthen material which has been compacted by a specific weight and procedure, at an optimum soil moisture, according to a laboratory engineering test developed by Proctor.

"State Solid Waste Management Plan" means the State plan adopted pursuant to Section 22a-211 of the Connecticut General Statutes, as amended.

"Stormwater" means precipitation runoff.

"Transfer station" means a volume reduction plant, as defined by Section 22a-207 of the General Statutes, as amended, that is a central collection point for the solid waste generated within a municipality or group of municipalities, where solid wastes received are transferred to a vehicle for removal to another solid waste facility.

"Underdrainage" means a system of pipes, structures, stone, pumps, wells, or other devices utilized to lower or divert groundwater.

"Vector" means as insect or rodent or other animal (not human) which can transmit infectious diseases from one person or animal to another person or animal.

"Vertical expansion" means an expansion of an existing solid waste disposal area such that future disposal of municipal solid waste will take place only where solid waste has previously been disposed of and is still present.

"Washout" means the carrying away of solid waste by waters of the base flood.

"Water Quality Standards" means the water quality standards and water quality Classifications Map published by the Connecticut Department of Environmental Protection, February, 1987.

"Water table" means that surface of a body of unconfined groundwater at which the pressure is equal to that of the atmosphere.

"Working face" means that portion of a solid waste or special waste disposal area where the waste is deposited, spread and compacted prior to the placement of cover material.

"Zone of influence" means the area in which, assuming the absence of any means at a solid waste facility to collect or treat leachate, groundwater may be altered in quality due to discharge of leachate from any portion of such facility.

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APPROVED CRITERIA FOR ADDITIONAL POLLUTING SUBSTANCES

Approved Criteria for Additional Polluting Substances

Pursuant to Sections 22a-133k(1) through (3) of the Regulations of Connecticut State Agencies

Pollutant	Soil (mg/kg)					Groundwater (µg/l)			
	RES DEC	I/C DEC	GAA/ GA PMC	GB PMC	GWPC	SWPC	RES VC	I/C VC	
acenaphthene	1000	2500	8.4	84	420	NE	NE	NE	
aldrin	0.036	0.34	In Review	In Review	In Review	NE	NE	NE	
benzo(g,h,i)perylene ⁸	1000	2500	4.2	42	210	NE	NE	NE	
benzoic acid	1000	2500	1000	10000	50000	NE	NE	NE	
BHC(alpha-)	0.097	0.91	In Review	In Review	In Review	NE	NE	NE	
BHC(beta-)	0.34	3.2	In Review	In Review	In Review	NE	NE	NE	
BHC(delta) ¹	0.097	0.91	In Review	In Review	In Review	NE	NE	NE	
bromodichloromethane	9.9	92	0.011	0.11	0.56	NE	NE	NE	
bromomethane	95	1000	0.2	2	9.8	NE	NE	NE	
4-bromophenyl-phenylether	500	1000	8.2	82	410	NE	NE	NE	
n-butylbenzene	500	1000	1.4	14	61 ¹³	NE	NE	NE	
sec-butylbenzene	500	1000	1.4	14	61 ¹³	NE	NE	NE	
tert-butylbenzene	500	1000	1.4	14	61 ¹³	NE	NE	NE	
carbazole	31	290	1 #	1 #	10 #	NE	NE	NE	

Approved Criteria for Additional Polluting Substances
Pursuant to Sections 22a-133k(1) through (3) of the Regulations of Connecticut State Agencies

Pollutant	Soil (mg/kg)					Groundwater (µg/l)			
	RES DEC	I/C DEC	GAA/ GA PMC	GB PMC	GWPC	SWPC	RES VC	I/C VC	
carbon disulfide	500	1000	14	140	700	NE	NE	NE	
4-chloroaniline	270	2500	1 #	5.6	28	NE	NE	NE	
chloromethane	47	440	0.054	0.54	2.7	NE	NE	NE	
2-chloronaphthalene	1000	2500	11	110	560	NE	NE	NE	
4-chlorophenyl-phenyl ether ²	500	1000	8.2	82	410	NE	NE	NE	
chrysene	84	780	1 #	1 #	4.8	NE	NE	NE	
m-cresol	1000	2500	7	70	350	NE	NE	NE	
p-cresol	340	2500	0.7	7	35	NE	NE	NE	
4,4'-DDD	2.6	24	In Review	In Review	0.15	NE	NE	NE	
4,4'-DDE	1.8	17	In Review	In Review	0.1	NE	NE	NE	
4,4'-DDT	1.8	17	In Review	In Review	0.1	NE	NE	NE	
dibenzofuran	270	2500	1 #	5.6	28	NE	NE	NE	
dibenz(a,h)anthracene	1 #	1 #	1 #	1 #	0.5 #	NE	NE	NE	

Approved Criteria for Additional Polluting Substances

Pursuant to Sections 22a-133k(1) through (3) of the Regulations of Connecticut State Agencies

Pollutant	Soil (mg/kg)					Groundwater (µg/l)			
	RES DEC	I/C DEC	GAA/ GA PMC	GB PMC	GWPC	SWPC	RES VC	I/C VC	
1,2-dibromo-3-chloropropane	0.44	4.1	In Review	In Review	In Review	NE	NE	NE	
1,2-dibromoethane	0.0072	0.067	In Review	In Review	In Review	NE	NE	NE	
3,3'-dichlorobenzidene	1.4	13	0.33 #	0.33 #	10 #	NE	NE	NE	
1,4-dichlorobutene	0.07	0.62	In Review	In Review	In Review	NE	NE	NE	
diethyl phthalate	1000	2500	110	1100	5600	NE	NE	NE	
2,4-dimethylphenol	1000	2500	2.8	28	140	NE	NE	NE	
dimethyl phthalate ¹⁰	1000	2500	110	1100	5600	NE	NE	NE	
2,4-dinitrophenol	140	2500	1.65 #	2.8	50 #	NE	NE	NE	
2,4-dinitrotoluene	140	2500	1 #	2.8	14	NE	NE	NE	
2,6-dinitrotoluene	68	2000	1 #	1.4	10 #	NE	NE	NE	
endosulfan I	410	1200	0.84	8.4	42	NE	NE	NE	
endosulfan II	410	1200	0.84	8.4	42	NE	NE	NE	
endosulfan sulfate ³	410	1200	0.84	8.4	42	NE	NE	NE	

Approved Criteria for Additional Polluting Substances

Pursuant to Sections 22a-133k(1) through (3) of the Regulations of Connecticut State Agencies

Pollutant	Soil (mg/kg)					Groundwater (µg/l)			
	RES DEC	I/C DEC	GAA/ GA PMC	GB PMC	GWPC	SWPC	RES VC	I/C VC	
endrin aldehyde ⁴	20	610	NE	NE	NE	NE	NE	NE	
endrin ketone ⁵	20	610	NE	NE	NE	NE	NE	NE	
hexachlorobutadiene	7.9	73	1 #	1 #	0.45	NE	NE	NE	
hexachlorocyclopentadiene	470	2500	1 #	9.8	49	NE	NE	NE	
indeno(1,2,3-cd)pyrene	1 #	7.8	1 #	1 #	0.5 #	NE	NE	NE	
isophorone	640	2500	1 #	7.4	37	NE	NE	NE	
isopropylbenzene (cumene)	500	1000	0.6	132 ¹⁴	30 ¹⁵	NE	NE	NE	
4-isopropyltoluene (p-cymene)	500	1000	0.6	41.8	30 ¹⁵	NE	NE	NE	
p-isopropyltoluene ⁹	NE	NE	1.4	14	70	NE	NE	NE	
2-methylnaphthalene ⁷	474	2500	0.98	9.8	49	NE	NE	NE	
2-methylphenol	1000	2500	7	70	350	NE	NE	NE	
4-methylphenol	340	2500	1 #	7	35	NE	NE	NE	
2-nitroaniline	4.1	1200	1.65 #	1.65 #	50 #	NE	NE	NE	

Approved Criteria for Additional Polluting Substances
Pursuant to Sections 22a-133k(1) through (3) of the Regulations of Connecticut State Agencies

Pollutant	Soil (mg/kg)					Groundwater (µg/l)			
	RES DEC	I/C DEC	GAA/ GA PMC	GB PMC	GWPC	SWPC	RES VC	I/C VC	
3-nitroaniline	200	2500	1.65 #	4.2		NE	NE	NE	
4-nitroaniline	200	2500	1 #	4.2	21	NE	NE	NE	
nitrobenzene	34	1000	1 #	1 #	10 #	NE	NE	NE	
2-nitrophenol	540	2500	1.1	11	56	NE	NE	NE	
N-nitrosodiphenylamine	130	1200	1 #	1.4	10 #	NE	NE	NE	
N-nitrosodi-n-propylamine	1 #	1 #	1 #	1 #	10 #	NE	NE	NE	
n-propylbenzene	500	1000	1.4	14	61 ¹³	NE	NE	NE	
1,2,4-trichlorobenzene	680	2500	1.4	14	70	NE	NE	NE	
trichloroflouroethane ¹¹	NE	NE	NE	NE	20000	NE	NE	NE	
trichloroflouromethane	500	1000	26	260	1300	NE	NE	NE	
2,4,5-trichlorophenol	1000	2500	14	140	700	NE	NE	NE	
2,4,6-trichlorophenol	56	520	1 #	1 #	10 #	NE	NE	NE	
1,2,4-trimethylbenzene	500	1000	7	70	350	NE	NE	NE	
1,3,5-trimethylbenzene	500	1000	7	70	350	NE	NE	NE	

Approved Criteria for Additional Polluting Substances

Pursuant to Sections 22a-133k(1) through (3) of the Regulations of Connecticut State Agencies

NE #	Not Established Criteria based on detection limits.
Notes:	¹ BCH(alpha) used as surrogate for BCH (delta). ² 4-bromophenyl-phenyl ether used as surrogate for 4-chlorophenyl-phenyl ether. ³ Endosulfan used as surrogate for endosulfan sulfate. ⁴ Endrin used as surrogate for endrin aldehyde. ⁵ Endrin used as surrogate for endrin ketone. ⁷ Based on an interim acceptable exposure level of 0.007 mg/kg developed by DPH. Criteria to be used for screening purposes. ⁸ Pyrene used as surrogate for benzo(g,h,i)perylene. ⁹ Screening level for p-isopropyltoluene is based on isopropylbenzene as a surrogate. Also known as methylisopropylbenzene. ¹⁰ Diethyl phthalate used as surrogate for dimethyl phthalate. ¹¹ Based on odor threshold. Also known as Freon 113 and 1,1,2-trichloro-1,2,2-trifluoroethane. ¹² Based on health based GWPC of 209 μ g/l; toxicity is estimated to be three fold greater than cumene. ¹³ GWPC from Region III table which incorporates inhalation and drinking exposure routes. ¹⁴ Based on health based GWPC of 660 μ g/l. ¹⁵ GWPC based on odor detection from volatilization during showering.

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**PROPOSED REVISIONS
CONNECTICUT'S REMEDIATION STANDARD REGULATIONS
VOLATILIZATION CRITERIA**

Proposed Revisions

Connecticut's Remediation Standard Regulations Volatilization Criteria

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INTRODUCTION

The volatilization criteria were developed to identify situations where contaminants in groundwater and soil vapor volatilize, travel into an overlying building and result in the potential risk to human health from the inhalation of the contaminants by occupants of the building. Since the development and adoption of the volatilization criteria in the Remediation Standard Regulations (RSRs) in 1996, the Department of Environmental Protection (DEP), the Department of Public Health (DPH), the U.S. Environmental Protection Agency (USEPA), other state agencies and researchers across the country have collected additional laboratory and field information regarding the volatilization of contaminants. This work has resulted in a better understanding of the vapor migration pathway and the associated risk to public health posed by volatile organic compounds present in the subsurface. Consequently, DEP, with the assistance and input of DPH, is proposing revisions to the volatilization criteria. This document describes the basis for the proposed criteria, as well as the basis for the original criteria issued in 1996 for comparison.

The proposed revisions reflect new toxicological information, a revised transport model and additional information and understanding of this potential pathway of exposure that have all become available since the RSRs were formally adopted in 1996. The proposed revised target indoor air concentrations, groundwater volatilization criteria and soil vapor volatilization criteria are presented in Tables 1, 2 and 3, respectively.

The CTDEP is proposing revisions to the volatilization criteria at this time as part of the Department's application to the USEPA for authorization of the RCRA Corrective Action Program. These proposed changes make Connecticut's criteria more consistent with the EPA Draft Guidance "Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soil" that was issued in November 2002.

BASIS FOR DEVELOPMENT OF ORIGINAL VOLATILIZATION CRITERIA

The numerical volatilization criteria adopted in 1996 are listed in Appendices E and F of the RSRs and also in Tables C1, C2 and C3 in Appendix C of this document. These numerical criteria were developed using the transport model presented in ASTM ES 38-94 "Emergency Standard Guide for Risk Based Corrective Action Applied at Petroleum Release Sites" and toxicity information that was available in 1995.

Original Transport Model

The original transport model presented in the ASTM ES 38-94 was based on a model developed by Johnson and Ettinger and utilized a simplified approach for simulating the transport of volatiles from groundwater, through the soil media and building foundations, and into building structures as airborne contaminants. That model was based on the assumption that diffusion is the sole method of transport from subsurface contamination into the indoor air environment. Diffusion is the process resulting from random motion of molecules by which there is a net flow of matter from a region of high concentration to a region of low concentration. Equations used to develop the original volatilization criteria are shown in Appendix G of the RSRs and in Tables X2.1, X2.2, and X2.3 of ASTM ES 38-94.

The original transport model required the input of a variety of parameters to define the subsurface conditions, the building foundation and the interior environment of the building. Since these parameters are widely variable depending on site-specific conditions, default values were developed. Default values for the various parameters used in the model are presented in Appendix G of the RSRs and are the default values recommended in Tables X2.4 and X2.5 of ASTM ES 38-94. In general, these input parameters describe a conservative scenario in an effort to best protect human health and the environment in the generic or broad application of these criteria.

Original Target Indoor Air Concentrations

The volatilization criteria were developed by calculating a target indoor air concentration (TAC) for each chemical using risk assessment algorithms and toxicity values recommended by USEPA in 1995 and exposure assumptions recommended in ASTM ES 39-94. Background concentrations for certain chemicals were also taken into consideration when establishing the TACs. The background concentrations were described in Table 4 of ASTM ES 38-94 and in Table 3-1 of Massachusetts DEP's "Background Documentation for the Development of the MCP Numerical Standards". For some chemicals, the background concentrations were greater than the calculated risk-based concentrations. For these chemicals, the TACs were set at the background concentrations.

Ceiling Value for Groundwater Volatilization Criteria

A ceiling value of 50,000 micrograms per liter ("µg/L") was applied to all of the groundwater volatilization criteria for which the risk-based criteria were greater than 50,000 µg/L. The purpose of the ceiling value was to prevent gross contamination from being overlooked and to ensure that remediation in accordance with these criteria would address potential odor problems.

Quantification Limits

In general, if the risk-based criteria for a contaminant in soil, groundwater or soil vapor was a concentration lower than that which could be reasonably quantified, the RSR criteria was adjusted upward to a level that could be quantified by laboratories in Connecticut. In 1996, the soil vapor volatilization criteria were adjusted such that any risk-based soil vapor volatilization criteria that was determined to be less than one part per million ("ppm") was adjusted up to 1 ppm.

PROPOSED REVISIONS TO THE VOLATILIZATION CRITERIA

The proposed volatilization criteria are based on:

- 1) The Johnson and Ettinger (1991) model, incorporating its extensions developed in 1998 and 1999 (Johnson et al. 1998 and Johnson et al. 1999),
- 2) New toxicity information,
- 3) New exposure assumptions,
- 4) Ceiling values for target indoor air concentrations, and
- 5) Updated quantification limits.

Proposed revised target indoor air concentrations, groundwater volatilization criteria and soil vapor volatilization criteria are shown in Tables 1, 2 and 3 of this document.

Revised Transport Model

The revised Johnson and Ettinger model incorporates both diffusion and advection as the mechanisms of transport of subsurface contamination into the indoor air environment. While diffusion is a passive process, advection is an active process brought about by pressure gradients. Gases will move from areas of high pressure to areas of low pressure. Buildings, particularly under wintertime conditions, are depressurized due to warmed air constantly rising towards the roof. This allows influx of air from the soil gas, which follows the pressure gradient from soil gas into the basement. The greater the depressurization of the building, the greater the zone of influence will be. The zone of influence is the depth from which soil gas can be drawn into the building.

Since the revised model incorporates both diffusion and advection as transport mechanisms, the total amount of transport is greater than that calculated using the original model. Sampling at sites in Connecticut show that the original model under-predicted indoor air concentrations based on groundwater and soil vapor sample results. Therefore, the revised model provides a more accurate and realistic representation of volatile transport. USEPA is also currently using the revised Johnson and Ettinger model to develop their "Guidance for Evaluating the Vapor Intrusion into Indoor Air". In addition, many states including Massachusetts, Michigan, Pennsylvania, Virginia, West Virginia and California are also using this model to develop criteria for this exposure pathway. Appendix A describes the revised model in detail.

The default input values used in the revised model are the same as those used in the 1996 model with one exception, Q_{soil}/Q_B . Q_{soil}/Q_B is the ratio of soil gas intrusion rate to building ventilation rate and was not part of the original model. The default input value used for Q_{soil}/Q_B is taken from USEPA's "Guidance for Evaluating the Vapor Intrusion into Indoor Air". All variables used in the revised model are listed and defined in Tables A1 and A2. Table A3 shows the typical values or range of values for these parameters as well as the default values used to calculate the proposed volatilization criteria.

Revised and Updated Target Indoor Air Concentrations

The target indoor air concentrations (TACs) were again derived by CT DPH for each chemical using risk-based calculations recommended by USEPA, the chemical-specific reference concentrations (RfCs) and cancer unit risks currently available. Appendix B presents these risk-based equations. The following issues were addressed in the TAC revisions:

- 1) Updated toxicity values,
- 2) Revised exposure assumptions for industrial/commercial settings,
- 3) Increased exposure and susceptibility for children for residential settings,
- 4) Updated background concentrations, and
- 5) Ceiling value for TACs.

Toxicity Values

All of the toxicity values have been reviewed and revised to reflect up-to-date toxicity values. The most significant changes are the toxicity values for several chlorinated hydrocarbons including 1,1-dichloroethylene ("DCE"), trichloroethylene ("TCE"), and vinyl chloride. 1,1-Dichloroethylene is no longer regulated as a low dose linear carcinogen; although, there remains considerable uncertainty regarding its potential carcinogenicity, which is reflected in the new TAC. The net result of this is an increase in the 1,1-DCE TAC by 200 fold over the former value. The evidence for the carcinogenicity of trichloroethylene in humans has become strengthened with an associated increase in USEPA's estimate of its cancer potency (Cogliano, et al., 2001). This change would have led to a considerable lowering of the TCE TAC, if not for the fact that TCE is a background indoor air contaminant. Setting the TAC for TCE at its background concentration leads to a 5 fold lowering of the TAC, relative to the 1996 value. USEPA's carcinogenicity reassessment of vinyl chloride has led to a decrease in its potency estimate by 10 fold, leading to a commensurate increase in the TAC for vinyl chloride.

While USEPA's Integrated Risk Information System (IRIS) database was relied upon as the primary source of toxicity values, other federal and state risk assessment databases (USEPA's Health Effects Assessment Summary Tables – HEAST, ATSDR's Chronic Minimum Risk Levels – MRLs, California EPA's Chronic RELs) were reviewed to determine the consistency of toxicity values across agencies. These other data sources were used in derivation of TACs in cases where USEPA did not have a value listed on IRIS. Appendix B presents all of the new toxicity values and how they were used in deriving TACs for both residential and industrial/commercial scenarios.

Exposure Assumptions

Exposure assumptions for the residential scenario have not changed: 30 year residence at the affected location, daily exposure for 350 days/year, with an inhalation rate of 20 m³/day for a 70 kg adult. The exposure assumptions for the industrial/commercial scenario are revised to better reflect likely workplace exposures. The inhalation rate per day has been reduced by one half to 10 m³/day to reflect a shorter exposure time in the industrial/commercial exposure scenario. The other exposure assumptions for this scenario have not changed (25 years exposure, 250 days/year, 70 kg body weight).

Increased Exposure and Susceptibility of Children to Carcinogens

Increased exposure and susceptibility of children in a residential scenario to carcinogens was taken into consideration during these revisions. The residential scenario involves young children, which is a receptor group that is likely to be at elevated risk relative to adults due to several factors: 1) their greater respiratory rate per body weight and lung surface area (Child-Specific Exposure Factors Handbook, USEPA, 2000; Thurlbeck, 1982); and 2) due to the likelihood that they have increased sensitivity to carcinogens (Ginsberg, 2003; USEPA, 2003; USEPA, 2000). TACs based on adult exposure parameters and sensitivity may not be adequately protective of children.

The first factor, children's increased inhalation rate, is the basis for a 2-fold adjustment of the TAC to ensure protection of children.

The second factor, increased sensitivity to carcinogens, was the rationale for an additional 2-fold adjustment factor, but in this case it is applied only for genotoxic carcinogens. Juvenile animal studies indicate that even very brief exposures in early life can lead to substantial cancer risk (Vessinovitch, 1979; Toth, 1968). However, the standard rodent cancer bioassay upon which unit risks are derived starts dosing after this period of development. For these reasons, the development of TACs for the residential scenario incorporates a children's carcinogen sensitivity factor. This factor is applied to genotoxicants, a type of carcinogen whose effects in early life are most clearly documented at the present time. The adjustment factor is 2 fold based upon the vinyl chloride example on IRIS (USEPA, 2000). The underlying principle is that the risk from short-term early life exposure can be equal to the risk stemming from much longer exposure beginning later in life, and that risks must be additive across these age groups (Ginsberg, 2003). This approach is consistent with USEPA's IRIS file for vinyl chloride and draft Cancer Risk Assessment Guidelines (USEPA, 2000; USEPA, 2003).

Background Concentrations in Indoor Air

Since 1996, there has been an increased focus around the United States on measuring indoor air quality in impacted and non-impacted (or "background") homes, offices, schools and other environments. This had led to an enhanced database for background indoor air data (Foster, et al., 2002; Kurtz and Folkes, 2002; NYSDOH, 1997; Clayton, et al., 1999; Shields, et al., 1996; USEPA/BASE Study, 1999). These datasets, along with the pre-existing indoor air datasets (Stolwick, 1990; Vermont DOH, 1992; Brown, et al., 1994; Daisey, et al., 1994; Sheldon, et al., 1992; Shah and Singh, 1988) have been reviewed while giving particular attention to those volatile organic compounds (VOCs) (typically carcinogens) with risk-based TACs that approach or are below what can be considered background. VOC indoor air measurements are typically lognormally distributed; therefore, the central tendency background concentration (the median) was chosen to represent background. While higher concentrations may be found in certain background locations, the central tendency was used because of the way it would be applied: 1) to replace a risk-based TAC such that the background concentration would already be above a risk target; and 2) to back-calculate the allowable contribution from subsurface VOC contamination, such that the amount that is from background sources plus the amount allowed from subsurface sources would still be within the range of the background data distribution.

VOC background concentrations and how they are used in the derivation of TACs are shown chemical-by-chemical in Appendix B.

TAC Ceiling Value

A ceiling value of 500 ug/m³ was applied to both the residential and industrial/commercial scenarios for those VOCs with risk-based TACs exceeding

this ceiling value. This ceiling value was derived as an upper bound concentration that signals the presence of an unusual indoor air source for an individual VOC. It is prudent to keep the concentration of individual VOCs below this level to avoid odor complaints, degraded air quality, or non-specific health complaints. VOC odor thresholds were separately considered but only in isolated cases where the odor threshold is the key factor in setting a TAC. Appendix B provides a detailed discussion of this topic.

Current Quantification Limits

Based on the use of current analytical methods, concentrations in soil vapor can be reliably quantified at a level significantly lower than 1ppm. Therefore, the soil vapor volatilization criteria were adjusted such that any risk-based soil vapor volatilization criteria that are determined to be less than 0.5 ppb, are adjusted up to 0.5 ppb. The only criteria adjusted up to 0.5 ppb, is the residential soil vapor volatilization criteria for ethylene dibromide (EDB).

Criteria for New Chemicals

Since 1996, the DEP has approved volatilization criteria for a number of compounds for which criteria had not been established in the original regulations. Based on all of the requests for additional criteria for additional chemicals submitted since 1996, the following compounds have been added to the list of volatilization criteria: trichlorofluoromethane, chloroethane, chloromethane, dichlorodifluoromethane, isopropylbenzene (cumene), cis-1,2-dichloroethene, trans-1,2-dichloroethene, bromodichloromethane, n-butylbenzene, sec-butylbenzene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene and 4-isopropyltoluene (4-cymene).

APPLICATION OF THE VOLATILIZATION CRITERIA

Under the current regulations, the groundwater volatilization criteria are applicable to “all ground water polluted with a volatile organic substance within 15 feet of the ground surface or a building”. However, research since 1996 has demonstrated that volatiles in groundwater at depths much deeper than 15 feet have been the source of vapor intrusion into overlying structures at concentrations that pose a risk to public health. The USEPA in their “Guidance for Evaluating the Vapor Intrusion into Indoor Air” is recommending applying criteria up to buildings up to 100 feet from the contamination source. Other states including Michigan and Pennsylvania require that volatilization issues be addressed when polluted ground water is within 30 feet of the surface. After evaluating geology and hydrogeology in Connecticut, DEP is proposing that the volatilization criteria should be applied to groundwater within 30 feet of the ground surface or a building.

The RSRs adopted in 1996 provide baseline numeric criteria that can be used to demonstrate compliance or that can be used as a screening level. The regulations also provide the option of developing a site-specific criteria by calculating an attenuation factor using input parameters that are appropriate for the circumstances at a specific site. The site-specific option will also be retained in the proposed revisions to the regulations. However, the revised Johnson and Ettinger model should be used for such calculations. Further, the option to take measures that would prevent the migration of volatiles into indoor air rather than remediate the ground water

and the option to record a land use restriction that would prohibit the construction of a building over ground water polluted by VOCs will be retained in the revised regulations.

SUMMARY

DEP is proposing to revise the volatilization criteria to better protect human health and to remain consistent with federal programs. The revisions proposed in this document are in keeping with the following objectives:

- The proposed revised volatilization criteria are similar to those used by USEPA and other states.
- The revised transport model more accurately predicts indoor air concentrations.
- The toxicity information has been updated to current toxicity values.
- The exposure assumptions have been refined to be both protective and realistic.
- The depth to groundwater to which these criteria should be applied has been increased to 30 feet based on new research that demonstrates indoor exposures resulting from the migration of volatiles from a ground water source significantly deeper than 15 feet.

A comparison of 1996 TACs and volatilization criteria to proposed revised TACs and volatilization criteria is presented in the three tables in Appendix C.

DEP is seeking comments from the public on these revisions before proposing revised regulations in July 2003. Please send you comments to:

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Table 1
Proposed Target Indoor Air Concentrations

Compound	CAS Number	Residential TAC (ug/m ³)	Industrial/Commercial TAC (ug/m ³)
Acetone	67641	180	500 ⁽¹⁾
Acrylonitrile	107131	NA	NA
Benzene	71432	3.3 ⁽²⁾	3.3 ⁽²⁾
Bromoform	75252	0.55	7.3
2-Butanone (MEK)	78933	500 ⁽¹⁾	500 ⁽¹⁾
Carbon tetrachloride	56235	0.5 ⁽²⁾	0.54 ⁽²⁾
Chlorobenzene	108907	37	200
Chloroform	67663	0.5 ⁽²⁾	0.5 ⁽²⁾
Dibromochloromethane	124481	NA	NA
1,2-Dichlorobenzene	95501	73	410
1,3-Dichlorobenzene	541731	73	410
1,4-Dichlorobenzene	106467	24	24
1,1-Dichloroethane	75343	77	430
1,2-Dichloroethane	107062	0.07	0.31
1,1-Dichloroethylene	75354	10	20
cis-1,2-Dichloroethylene	156592	See New Criteria below	See New Criteria below
trans-1,2-Dichloroethylene	156605	See New Criteria below	See New Criteria below
1,2-Dichloropropane	78875	0.13	0.42
1,3-Dichloropropene	542756	0.21	2.9
Ethyl benzene	100414	53	290
Ethylene dibromide (EDB)	106934	0.0028	0.038
Methyl-tert-butyl-ether	1634044	160	190 ⁽³⁾
Methyl isobutyl ketone	108101	37	200
Methylene chloride	75092	3 ⁽²⁾	17
Styrene	100425	52	290

Table 1
(Continued)

Proposed Target Indoor Air Concentrations

Compound	CAS Number	Residential TAC (ug/m ³)	Industrial/Commercial TAC (ug/m ³)
1,1,1,2-Tetrachloroethane	630206	0.082	1.1
1,1,2,2-Tetrachloroethane	79345	0.011	0.14
Tetrachloroethylene	127184	5 ⁽²⁾	5 ⁽²⁾
Toluene	108883	210	500 ⁽¹⁾
1,1,1 Trichloroethane	71556	500	500 ⁽¹⁾
1,1,2-Trichloroethane	79005	2.2	12
Trichloroethylene	79016	1 ⁽²⁾	1 ⁽²⁾
Vinyl chloride	75014	0.14	1.9
Xylenes	1330207	220	500 ⁽¹⁾
New Criteria			
Trichlorofluoromethane	75694	370	500 ⁽¹⁾
Chloroethane	75003	500 ⁽¹⁾	500 ⁽¹⁾
Chloromethane	74873	14	80
Dichlorodifluoromethane	75718	91	500 ⁽¹⁾
Isopropylbenzene (Cumene)	98828	120 ⁽³⁾	120 ⁽³⁾
cis-1,2-dichloroethene	156592	18	100
trans-1,2-dichloroethene	156605	37	200
Bromodichloromethane	75274	0.034	0.46
N-butylbenzene	104518	73	410
Sec-butylbenzene	135988	73	410
1,2,4-trimethylbenzene	95636	9.3	52
1,3,5-trimethylbenzene	108678	9.3	52
4-isopropyltoluene (4-cymene)	99876	67	370

⁽¹⁾ Based on a ceiling value. ⁽²⁾ Based on a background concentration.

⁽³⁾ Based on an odor threshold concentration.

Table 2**Proposed Ground Water Volatilization Criteria**

Compound	CAS Number	Residential GWVC (ug/L)	Industrial/Commercial GWVC (ug/L)
Acetone	67641	50000	50000
Acrylonitrile	107131	NA	NA
Benzene	71432	130	310
Bromoform	75252	75	2300
2-Butanone (MEK)	78933	50000	50000
Carbon tetrachloride	56235	5.3	14
Chlorobenzene	108907	1800	23000
Chloroform	67663	26	62
Dibromochloromethane	124481	NA	NA
1,2-Dichlorobenzene	95501	5100	50000
1,3-Dichlorobenzene	541731	4300	50000
1,4-Dichlorobenzene	106467	1400	3400
1,1-Dichloroethane	75343	3000	41000
1,2-Dichloroethane	107062	6.5	68
1,1-Dichloroethylene	75354	190	920
cis-1,2-Dichloroethylene	156592	See New Criteria below	See New Criteria below
trans-1,2-Dichloroethylene	156605	See New Criteria below	See New Criteria below
1,2-Dichloropropane	78875	7.4	58
1,3-Dichloropropene	542756	11	360
Ethyl benzene	100414	2700	36000
Ethylene dibromide (EDB)	106934	0.3	11
Methyl-tert-butyl-ether	1634044	21000	50000
Methyl isobutyl ketone	108101	13000	50000
Methylene chloride	75092	160	2200
Styrene	100425	3100	42000

Table 2
(Continued)

Proposed Ground Water Volatilization Criteria

Compound	CAS Number	Residential GWVC (ug/L)	Industrial/Commercial GWVC (ug/L)
1,1,1,2-Tetrachloroethane	630206	2	64
1,1,2,2-Tetrachloroethane	79345	1.8	54
Tetrachloroethylene	127184	340	810
Toluene	108883	7100	41000
1,1,1 Trichloroethane	71556	6500	16000
1,1,2-Trichloroethane	79005	220	2900
Trichloroethylene	79016	27	67
Vinyl chloride	75014	1.6	52
Xylenes	1330207	8700	48000
New Criteria			
Trichlorofluoromethane	75694	1300	4200
Chloroethane	75003	12000	29000
Chloromethane	74873	390	5500
Dichlorodifluoromethane	75718	93	1200
Isopropylbenzene (Cumene)	98828	2800	6800
Cis-1,2-dichloroethene	156592	830	11000
trans-1,2-dichloroethene	156605	1000	13000
Bromodichloromethane	75274	2.3	73
N-butylbenzene	104518	1500	21000
Sec-butylbenzene	135988	1500	20000
1,2,4-trimethylbenzene	95636	360	4800
1,3,5-trimethylbenzene	108678	280	3900
4-isopropyltoluene (4-cymene)	99876	1600	22000

Table 3**Proposed Soil Vapor Volatilization Criteria**

Compound	CAS Number	Residential SVVC (ppm)	Industrial/Commercial SVVC (ppm)
Acetone	67641	57	290
Acrylonitrile	107131	NA	NA
Benzene	71432	0.78	1.4
Bromoform	75252	0.04	0.98
2-Butanone (MEK)	78933	130	230
Carbon tetrachloride	56235	0.06	0.12
Chlorobenzene	108907	6.1	60
Chloroform	67663	0.078	0.14
Dibromochloromethane	124481	NA	NA
1,2-Dichlorobenzene	95501	9.2	95
1,3-Dichlorobenzene	541731	9.2	95
1,4-Dichlorobenzene	106467	3	5.5
1,1-Dichloroethane	75343	14	150
1,2-Dichloroethane	107062	0.013	0.11
1,1-Dichloroethylene	75354	1.9	7
cis-1,2-Dichloroethylene	156592	See New Criteria below	See New Criteria below
trans-1,2-Dichloroethylene	156605	See New Criteria below	See New Criteria below
1,2-Dichloropropane	78875	0.021	0.13
1,3-Dichloropropene	542756	0.035	0.89
Ethyl benzene	100414	9.3	93
Ethylene dibromide (EDB)	106934	0.0005	0.007
Methyl-tert-butyl-ether	1634044	34	73
Methyl isobutyl ketone	108101	6.8	68
Methylene chloride	75092	0.65	6.8
Styrene	100425	9.3	95

Table 3
(Continued)

Proposed Soil Vapor Volatilization Criteria

Compound	CAS Number	Residential SVVC (ppm)	Industrial/Commercial SVVC (ppm)
1,1,1,2-Tetrachloroethane	630206	0.009	0.22
1,1,2,2-Tetrachloroethane	79345	0.0012	0.028
Tetrachloroethylene	127184	0.56	1
Toluene	108883	42	180
1,1,1 Trichloroethane	71556	70	130
1,1,2-Trichloroethane	79005	0.31	3.1
Trichloroethylene	79016	0.14	0.26
Vinyl chloride	75014	0.041	1
Xylenes	1330207	38	160
New Criteria			
Trichlorofluoromethane	75694	50	120
Chloroethane	75003	140	260
Chloromethane	74873	5.1	53
Dichlorodifluoromethane	75718	14	140
Isopropylbenzene (Cumene)	98828	19	34
Cis-1,2-dichloroethene	156592	3.4	35
trans-1,2-dichloroethene	156605	7.1	70
Bromodichloromethane	75274	0.0038	0.095
N-butylbenzene	104518	10	100
Sec-butylbenzene	135988	10	100
1,2,4-trimethylbenzene	95636	1.4	15
1,3,5-trimethylbenzene	108678	1.4	15
4-isopropyltoluene (4-cymene)	99876	9.3	94

Appendix A

Johnson and Ettinger Model

APPENDIX A

JOHNSON AND ETTINGER MODEL

The revised Johnson and Ettinger model incorporates both diffusion and advection as mechanisms of transport of subsurface contamination into indoor air environment. Diffusion is the mechanism by which vapor moves from a region of higher concentration to a region of lower concentration. Diffusion is typically the vertical component of transport in this model. Advection is the transport mechanism by which vapor moves to a region where there is a difference in pressure, temperature or other factor. This Johnson and Ettinger model is the most widely used vapor transport model across the United States.

The Johnson and Ettinger model uses the conservation of mass principle and makes the following assumptions:

- Steady state conditions exist
- An infinite source of contamination exists
- The subsurface is homogeneous
- Air mixing in the building is uniform
- Preferential pathways do not exist
- Biodegradation (or any other transformation process) does not occur
- Contaminants are homogeneously distributed
- Contaminant vapors enter a building primarily through cracks and other openings in the foundation and walls
- Ventilation rates and pressure differences are assumed to remain constant

The output of the Johnson and Ettinger model is the dimensionless attenuation factor (α) that represents the ratio of the indoor air concentration to the vapor concentration at a subsurface source. Using the attenuation factor and the recommended target indoor air concentrations, allowable soil vapor and ground water concentrations were back calculated. These concentrations are the recommended volatilization criteria. The Connecticut Department of Public Health recommended appropriate target indoor air concentrations for residential and industrial/commercial scenarios.

- For ground water volatilization criteria:

$$\text{GWVC (ug/L)} = \text{Target Indoor Air Concentration (}\mu\text{g/m}^3\text{)} / (1000 \text{ L/m}^3 \times \alpha \times H)$$

where H = Henry's Law Constant (unitless)

- For soil vapor volatilization criteria:

$$\text{SVVC (mg/m}^3\text{)} = \text{Target Indoor Air Concentration (}\mu\text{g/m}^3\text{)} / (1000 \mu\text{g/mg} \times \alpha)$$

$$\text{SVVC (ppm)} = \text{SVVC (mg/m}^3\text{)} \times 24.45 / \text{Molecular Weight}$$

where 24.45 = molar volume in liters at 760 torr barometric pressure at 25 ° C

The Johnson and Ettinger model calculates the attenuation factor as follows:

Attenuation Factor for Diffusion and Advection –

$$\alpha = (A \times e^B) / [e^B + A + (A/C)(e^B - 1)]$$

where:

$$A = (D_T^{\text{eff}} A_B) / (Q_B L_T) \text{ or } (D_T^{\text{eff}}) / (E_B (V_B/A_B) L_T)$$

$$B = (Q_{\text{soil}} L_{\text{crack}}) / (D_{\text{crack}}^{\text{eff}} \eta A_B) \text{ or } [(Q_{\text{soil}}/Q_b) E_B (V_B/A_B) L_{\text{crack}}] / [D_{\text{crack}}^{\text{eff}} \eta]$$

$$C = Q_{\text{soil}}/Q_B$$

where:

$$D_T^{\text{eff}} = L_T / [(L_{\text{vadose}}/D_{\text{vadose}}^{\text{eff}}) + (L_{\text{cap}}/D_{\text{cap}}^{\text{eff}})]$$

$$D_{\text{crack}}^{\text{eff}} = D^{\text{air}} (\theta_{V\text{-crack}}^{3.33}/\theta_{T\text{-crack}}^2) + (D^{\text{water}}/H) (\theta_{m\text{-crack}}^{3.33}/\theta_{T\text{-crack}}^2)$$

where:

$$D_{\text{vadose}}^{\text{eff}} = D^{\text{air}} (\theta_{V\text{-vadose}}^{3.33}/\theta_{T\text{-vadose}}^2) + (D^{\text{water}}/H) (\theta_{m\text{-vadose}}^{3.33}/\theta_{T\text{-vadose}}^2)$$

$$D_{\text{cap}}^{\text{eff}} = D^{\text{air}} (\theta_{V\text{-cap}}^{3.33}/\theta_{T\text{-cap}}^2) + (D^{\text{water}}/H) (\theta_{m\text{-cap}}^{3.33}/\theta_{T\text{-cap}}^2)$$

The input values for these equations are defined in Tables A1 and A2 of this Appendix. Conservative default values for each input variable were used to calculate the generic volatilization criteria listed in Tables 2 and 3. The acceptable ranges for these default values are presented in Table A3 along with the default input values used by CTDEP to calculate the generic criteria. In addition, Table A4 presents molecular weights and Henry's Law Constants (H) used by CTDEP.

Basically the input values describe the vapor transport pathway including the

- subsurface soils and stratigraphy;
- foundation of the structure;
- interior environment of the structure; and
- transport properties of the contaminants.

The subsurface soils are assumed to be sand and the stratigraphy is assumed to be homogeneous. The default input values for the moisture content (θ_m) and vapor content (θ_v) of the soils in both the vadose zone and the capillary fringe were chosen to represent sandy soils in the subsurface. The thickness of the capillary fringe (L_{cap}) is also based on an estimated thickness of capillary fringe for a typical sand. The default input values used for the total depth (L_T) to groundwater and the total depth to a soil vapor sample are 3 meters and 1 meter, respectively.

The default values used to describe the foundation of the building are the thickness of the foundation (L_{crack}) assumed at 0.15 meters and the areal fraction of cracks in foundation (η) assumed at 0.01 (worst case value). Also, the soil properties of the soil in the cracks (θ_m and θ_v) are estimated based on a sand soil type. The default values used to describe the indoor

environment are the enclosed space air exchange rate (E_B), the volume of the building divided by the area of the building (or just the height of the building) (V_B/A_B) and the ratio of soil gas intrusion rate to the building ventilation rate (Q_{soil}/Q_B). These values differ for the residential scenario and the industrial commercial scenario.

The default values used to describe the transport properties of the contaminants are Henry's Law Constants (H) listed for specific chemical on Table A4, and the diffusion in water (D^{water}) and the diffusion in air (D^{air}). Though the diffusion rates can be chemical-specific, a general diffusion rates in air ($8.64 \times 10^{-5} \text{ M}^2/\text{d}$) and in water ($7.26 \times 10^{-1} \text{ M}^2/\text{d}$) were used for all of the chemicals.

All of the default input values used in this current model were also used in the original model with the exception of the ratio Q_{soil}/Q_B . This ratio was not part of the original model. The default input value used for Q_{soil}/Q_B is also the default value used in USEPA's "Guidance of reevaluating the Vapor Intrusion into Indoor Air" dated November 2002. The default input values used in the original model remain unchanged. The default values are those recommended by ASTM 38-94 in Tables X2.4 and X2.5.

The article written by Johnson titled "Identification of Critical Parameters for the Johnson and Ettinger (1991) Vapor Intrusion Model" dated May 2002 provides additional information regarding the input values and the sensitivity of the final attenuation factor to various input values.

The attenuation factors used to calculate the proposed revised criteria are based on the default input values listed in Table A3 and the revised Johnson and Ettinger model. In general, the attenuation factors used to calculate the proposed revised criteria are greater than the attenuation factors used to calculate the original criteria in 1996. For the ground water scenario, the attenuation factor increased by a multiple of approximately 2.5, from about 8×10^{-5} to 2×10^{-4} for the residential scenario and from 3×10^{-5} to 7×10^{-5} for the industrial/commercial scenario. For the soil vapor scenario, the attenuation factor increased by a multiple of approximately 10, from about 1.5×10^{-4} to 1.3×10^{-3} for residential the scenario and from 6×10^{-5} to 7×10^{-4} for the industrial/commercial scenario. The revised Johnson and Ettinger model produces a more conservative attenuation factor compared to the original model.

Table A1
Definition of Variables

	Definition	Units
H	Chemical Specific Henry's Law constant	$\mu\text{g}/\text{m}^3\text{-vapor} / \mu\text{g}/\text{m}^3\text{-H}_2\text{O}$
$\theta_{\text{m-vadose}}$	Volumetric Moisture Content in Vadose Zone	$\text{m}^3\text{-H}_2\text{O} / \text{m}^3\text{-soil}$
$\theta_{\text{T-vadose}}$	Total Porosity in Vadose Zone	$\text{m}^3\text{-voids} / \text{m}^3\text{-soil}$
$\theta_{\text{m-crack}}$	Volumetric Moisture Content in Cracks	$\text{m}^3\text{-H}_2\text{O} / \text{m}^3\text{-soil}$
$\theta_{\text{T-crack}}$	Total Porosity in Cracks	$\text{m}^3\text{-voids} / \text{m}^3\text{-soil}$
$\theta_{\text{m-cap}}$	Volumetric Moisture Content in Cracks in Capillary Fringe	$\text{m}^3\text{-H}_2\text{O} / \text{m}^3\text{-soil}$
$\theta_{\text{T-cap}}$	Total Porosity in Capillary Fringe	$\text{m}^3\text{-voids} / \text{m}^3\text{-soil}$
D^{air}	Chemical Specific Molecular Diffusion Coefficient in Air	m^2 / d
D^{water}	Chemical Specific Molecular Diffusion Coefficient in Water	m^2 / d
K	Soil Permeability (near foundation) to Air Flow	m^2
ΔP	Indoor-Outdoor Air Pressure Difference	g / ms^2
X_{crack}	Total Length of Cracks through which Soil Gas Vapors are Flowing	m
μ	Viscosity of Air	g / ms
Z_{crack}	Crack Opening Depth Below Grade	m
η	Fraction of Enclosed Space Area Open for Vapor Intrusion	m^2 / m^2
A_B	Surface Area of the Enclosed Space in Contact with Soil	m^2
V_B	Enclosed Space Volume	m^3
E_B	Enclosed Space Air Exchange Rate	1/d
L_T	Depth from Foundation to Source	m
L_{cap}	Thickness of Capillary Fringe	m
L_{crack}	Foundation Thickness	m

Table A2

Calculated Variables

	Definition	Calculation	Units
V_B/A_B	Ratio of Enclosed Space Volume to Exposed Surface Area		m
Q_B	Enclosed Space Volumetric Air Flow Rate	$= V_B E_B$	m^3 / d
R_{crack}	Effective Crack Radius or Width	$= \eta A_B / X_{crack}$	m
$\theta_{V-vadose}$	Volumetric Vapor Content in Vadose Zone	$= \theta_{T-vadose} - \theta_{m-vadose}$	$m^3\text{-vapor} / m^3\text{-soil}$
$\theta_{V-crack}$	Volumetric Vapor Content in Cracks	$= \theta_{T-crack} - \theta_{m-crack}$	$m^3\text{-vapor} / m^3\text{-soil}$
θ_{V-cap}	Volumetric Vapor Content in Capillary Fringe	$= \theta_{T-cap} - \theta_{m-cap}$	$m^3\text{-vapor} / m^3\text{-soil}$
Q_{soil}	Pressure Driven Soil Gas Flow Rate from the subsurface into the enclosed space	$= (2\pi k \Delta P X_{crack}) / [\mu \ln(2Z_{crack}/R_{crack})]$	m^3 / d
Q_{soil}/Q_B	Ratio of Soil Gas Intrusion Rate to Building Ventilation Rate		unitless
D_{water}/D_{air}	Ratio of Molecular Diffusion in water to air		unitless
L_{vadose}	Thickness of Vadose Zone	$= L_T - L_{cap}$	m

Table A3

Default Input Values

	Units	Typical Value Range ⁽¹⁾	Notes	Res GWVC	I/C GWVC	Res SVVC	I/C SVVC
H	$\mu\text{g}/\text{m}^3\text{-vapor} / \mu\text{g}/\text{m}^3\text{-H}_2\text{O}$	0.01 - 1.0	For most aromatic & chlorinated solvents	---	---	---	---
$\theta_{\text{m-vadose}}$	$\text{m}^3\text{-H}_2\text{O} / \text{m}^3\text{-soil}$		ASTM default value. Typical for sand.	0.12	0.12	0.12	0.12
$\theta_{\text{T-vadose}}$	$\text{m}^3\text{-voids} / \text{m}^3\text{-soil}$		ASTM default value. Typical for sand.	0.38	0.38	0.38	0.38
$\theta_{\text{m-crack}}$	$\text{m}^3\text{-H}_2\text{O} / \text{m}^3\text{-soil}$		ASTM default value. Typical for sand.	0.12	0.12	0.12	0.12
$\theta_{\text{T-crack}}$	$\text{m}^3\text{-voids} / \text{m}^3\text{-soil}$		ASTM default value. Typical for sand.	0.38	0.38	0.38	0.38
$\theta_{\text{m-cap}}$	$\text{m}^3\text{-H}_2\text{O} / \text{m}^3\text{-soil}$		ASTM default value. Typical for sand.	0.342	0.342	0.342	0.342
$\theta_{\text{T-cap}}$	$\text{m}^3\text{-voids} / \text{m}^3\text{-soil}$		ASTM default value. Typical for sand.	0.38	0.38	0.38	0.38
D^{air}	M^2 / d	0.1 - 1	For most chemicals	7.26E-01	7.26E-01	7.26E-01	7.26E-01
D^{water}	M^2 / d			8.64E-05	8.64E-05	8.64E-05	8.64E-05
k	m^2	1E-6 - 1E-12					
ΔP	g / ms^2	0 - 200	or 0 to 20 Pascals				
X_{crack}	m						
μ	g / ms						
Z_{crack}	m						
η	m^2 / m^2	0.0005 - 0.005	ASTM default value. 0.01 for worst-case scenario.	0.01	0.01	0.01	0.01
A_B	m^2						
V_B	m^3	147 - 672	Range from USDOE (1995)				
E_B	1/d	4.8 - 24	ASTM default values. 12 for Residential scenario and 19.9 for Industrial/Commercial scenario.	12	19.9	12	19.9
L_T	m	0.01 - 50	ASTM default values. 3 for Groundwater criteria and 1 for Soil Vapor criteria.	3	3	1	1
L_{cap}	m		ASTM default values. 0.05 for Groundwater criteria and 0 for Soil Vapor criteria.	0.05	0.05	0	0
L_{crack}	m	0.15 - 0.5	ASTM default value.	0.15	0.15	0.15	0.15

Table A3
(continued)

Default Input Values

	Units	Typical Value Range ⁽¹⁾	Notes	Res GWVC	I/C GWVC	Res SVVC	I/C SVVC
V_B/A_B	m	2 - 3	ASTM default values. 2 for Residential scenario and 3 for Industrial/Commercial scenario.	2	3	2	3
Q_B	m ³ / d						
R_{crack}	m						
$\theta_{V-vadose}$	m ³ -vapor / m ³ -soil		ASTM default value. Typical for sand.	0.26	0.26	0.26	0.26
$\theta_{V-crack}$	m ³ -vapor / m ³ -soil		ASTM default value. Typical for sand.	0.26	0.26	0.26	0.26
θ_{V-cap}	m ³ -vapor / m ³ -soil		ASTM default value. Typical for sand.	0.038	0.038	0.038	0.038
Q_{soil}	m ³ / d						
Q_{soil}/Q_B	unitless	0.0001 – 0.05	EPA Vapor Intrusion Guidance default value.	0.003	0.003	0.003	0.003
D^{water}/D^{air}	unitless	~ 1E-4		1.19E-04	1.19E-04	1.19E-04	1.19E-04
L_{vadose}	m		ASTM default value. 2.95 for Groundwater criteria and 1 for Soil Vapor criteria.	2.95	2.95	1	1

⁽¹⁾ Johnson, (2002), *Identification of Critical Parameters for the Johnson and Ettinger (1991) Vapor Intrusion Model*, API Bulletin #17, May.

Table A4

Henry's Law Constants and Molecular Weights

Compound	CAS Number	Henry's Law Constant (unitless)	Molecular Weight (g/mole)
Acetone	67641	1.75E-03	58
Acrylonitrile	107131		
Benzene	71432	2.26E-01	78
Bromoform	75252	2.18E-02	253
2-Butanone (MEK)	78933	1.12E-03	72
Carbon tetrachloride	56235	1.20E+00	154
Chlorobenzene	108907	1.61E-01	113
Chloroform	67663	1.39E-01	119
Dibromochloromethane	124481		
1,2-Dichlorobenzene	95501	7.95E-02	147
1,3-Dichlorobenzene	541731	1.08E-01	147
1,4-Dichlorobenzene	106467	1.12E-01	147
1,1-Dichloroethane	75343	2.23E-01	99
1,2-Dichloroethane	107062	4.51E-02	99
1,1-Dichloroethylene	75354	6.11E-01	97
cis-1,2-Dichloroethylene	156592	See listing below	See listing below
trans-1,2-Dichloroethylene	156605	See listing below	See listing below
1,2-Dichloropropane	78875	1.16E-01	113
1,3-Dichloropropene	542756	1.44E-01	111
Ethyl benzene	100414	1.41E-01	106
Ethylene dibromide (EDB)	106934	2.76E-02	188
Methyl-tert-butyl-ether	1634044	2.42E-02	88
Methyl isobutyl ketone	108101	5.66E-03	100
Methylene chloride	75092	1.31E-01	85
Styrene	100425	1.07E-01	104

Table A4
(Continued)

Henry's Law Constants and Molecular Weights

Compound	CAS Number	Henry's Law Constant (unitless)	Molecular Weight (g/mole)
1,1,1,2-Tetrachloroethane	630206	4.51E-01	168
1,1,2,2-Tetrachloroethane	79345	1.56E-02	168
Tetrachloroethylene	127184	8.36E-02	166
Toluene	108883	2.74E-01	92
1,1,1 Trichloroethane	71556	9.47E-01	133
1,1,2-Trichloroethane	79005	3.73E-02	133
Trichloroethylene	79016	3.74E-01	131
Vinyl chloride	75014	1.14E+00	63
Xylenes	1330207	2.16E-01	106
New Criteria			
Trichlorofluoromethane	75694	4.00E+00	137
Chloroethane	75003	4.50E-01	65
Chloromethane	74873	3.60E-01	51
Dichlorodifluoromethane	75718	1.40E+01	121
Isopropylbenzene (Cumene)	98828	4.70E-01	120
Cis-1,2-dichloroethene	156592	1.70E-01	97
trans-1,2-dichloroethene	156605	3.80E-01	97
Bromodichloromethane	75274	8.70E-02	164
N-butylbenzene	104518	5.24E-01	134
Sec-butylbenzene	135988	5.68E-01	134
1,2,4-trimethylbenzene	95636	2.30E-01	120
1,3,5-trimethylbenzene	108678	3.20E-01	120
4-isopropyltoluene (4-cymene)	99876	4.51E-01	134

Appendix B

Derivation of Target Indoor Air Concentrations

APPENDIX B

DERIVATION OF TARGET INDOOR AIR CONCENTRATIONS

This Appendix presents the derivation of target indoor air concentrations (TACs) for the volatile organic compounds (VOCs) listed in the existing Remediation Standard Regulations (RSR) volatilization criteria, together with TACs for 13 additional VOCs not previously listed. These additional VOCs though not originally listed, have appeared in groundwater and/or soil gas at sites in Connecticut. This Appendix includes two tables that list the TACs and the underlying toxicity values, modifying factors and background considerations. The following is a brief overview of the risk-based derivation methodology followed by the specific approaches used for the residential and industrial/commercial scenarios.

General TAC Methodology

TACs are air concentrations within homes or workplaces that are not expected to cause adverse health effects from chronic exposure. TACs rely upon chemical-specific toxicity values that describe the VOC's potency in terms of: 1) the reference concentration (RfC) - air concentration which will be free of risk for non-cancer health effects from chronic exposure; or 2) the unit risk factor - potency of VOC to produce carcinogenic effects per microgram per cubic meter ($\mu\text{g}/\text{m}^3$) of air chronically inhaled. These toxicity values are typically derived by USEPA from studies in which laboratory animals were exposed for chronic periods, with the toxic response based upon continuous exposure (24 hours per day (hr/d), every day of the year). Therefore, these targets need modification for exposure scenarios in which less than continuous exposure is likely (e.g., the industrial/commercial scenario). The TACs are set such that the lifetime cancer risk is at the de minimis risk level (one in a million or $1\text{E}-06$) and the hazard index (TAC/RfC_m where RfC_m is the RfC modified for the time-weight averaged amount of exposure in the specific scenario) for non-carcinogens is equal to unity.

While USEPA's Integrated Risk Information System (IRIS) database is the primary source of toxicology information for TAC development, other toxicology databases are also recognized as having well documented and widely used toxicity values. These include the Agency for Toxic Substances and Disease Registry (ATSDR)'s chronic Minimum Risk Levels (MRLs), California EPA's chronic Reference Exposure Levels (RELs) and USEPA's Health Effects Assessment Summary Tables (HEAST). In cases where a toxicity value was not available on IRIS, the value was sought from these other data sources. If still no value could be found, CTDPH conducted its own chemical-specific risk assessment. In certain cases, USEPA has listed provisional toxicity values that rely upon the best available science currently available, but these values may be somewhat more uncertain and are not supported by USEPA to the same extent as those values on IRIS. CTDPH has examined the basis for these particular values closely and, in isolated cases, has made adjustments.

A number of VOCs in the TAC list are possible rather than proven animal carcinogens, or, if proven, their cancer mechanism has uncertain relevance to low dose exposures in humans. These types of carcinogens were labeled as Group C carcinogens in USEPA's former cancer guidelines and are considered as Class 3 agents by IARC. Their carcinogenicity database is either too uncertain or incomplete to allow an extrapolation of risk to low dose human exposures. Rather than applying the classical low dose linear approach on the one hand, or ignoring their carcinogenic potential on the other, this derivation lowers the RfC by an uncertainty factor to account for this potential hazard. This approach is consistent with that developed by USEPA's Office of Drinking Water to establish Maximum Contaminant Levels

(MCLs). The default cancer uncertainty factor is 10 fold, although 3.33 fold (one half log lower) was used in cases where the uncertainty already built into the RfC was large (1000 fold or greater); this reduction in the cancer uncertainty factor was used to keep the overall uncertainty factor to less than 10,000.

In several cases toxicity values were available for the oral but not inhalation dose route. A dose route extrapolation to convert from the reference dose (in mg/kg/d) to RfC ($\mu\text{g}/\text{m}^3$) was used as long as the target site was not local to the site of bodily entry, but rather was at a systemic location (i.e., internal organs or systems).

The following are the general equations for the derivation of TACs. These equations and most of the parameter value inputs have not changed since the setting of the 1996 RSRs

For carcinogenic effects:
$$\text{TAC} = \frac{\text{TR} \times \text{BW} \times \text{AT}_c \times 365 \text{ d/yr} \times 10^3 \mu\text{g}/\text{mg}}{\text{SF}_i \times \text{IR}_{\text{air}} \times \text{EF} \times \text{ED}}$$

For non-carcinogenic effects:
$$\text{TAC} = \frac{\text{THQ} \times \text{BW} \times \text{RfD}_i \times \text{AT}_n \times 365 \text{ d/yr} \times 10^3 \mu\text{g}/\text{mg}}{\text{IR}_{\text{air}} \times \text{EF} \times \text{ED}}$$

where:

- AT_c = averaging time for carcinogens, years
Use $\text{AT}_c = 70$ years
- AT_n = averaging time for non-carcinogens, years
For residential use $\text{AT}_n = 30$ years
For commercial/industrial use $\text{AT}_n = 25$ years
- BW = adult body weight, kg
Use $\text{BW} = 70$ kg
- ED = exposure duration, years
For residential use $\text{ED} = 30$ years
For commercial/industrial use $\text{ED} = 25$ years
- EF = exposure frequency, days/years
For residential use $\text{EF} = 350$ days/year
For commercial/industrial use $\text{EF} = 250$ days/year
- IR_{air} = daily indoor inhalation rate, m^3/day
For residential use $\text{IR}_{\text{air}} = 20 \text{ m}^3/\text{day}$
For commercial/industrial use $\text{IR}_{\text{air}} = 10 \text{ m}^3/\text{day}$
- TAC = target indoor air concentration, $\mu\text{g}/\text{m}^3\text{-air}$
- RfD_i = inhalation chronic reference dose, $\text{mg}/\text{kg}\text{-day}$
Use numbers from IRIS and/or HEAST and/or other sources.
- SF_i = inhalation cancer slope factor, $\text{kg}\text{-day}/\text{mg}$
Use numbers from IRIS and/or HEAST and/or other sources.
- THQ = target hazard quotient for individual constituents, dimensionless
Use $\text{THQ} = 1$
- TR = target excess individual lifetime cancer risk, dimensionless
Use $\text{TR} = 1 \times 10^{-6}$

Modifications to the Residential Scenario

The exposure assumptions shown in the equations above pertain to adults (70 kg body weight, 20 m³/d inhalation rate). However, young children inhale more air per body weight and respiratory surface area than do adults (Child-Specific Exposure Factors Handbook, USEPA, 2000; Thurlbeck, 1982). This is an especially important consideration with regards to VOCs that can cause respiratory irritation and thus have the potential to exacerbate asthma due to the local dose in the lung. However, it also applies to systemic toxicants. The child/adult dose differential from inhalation exposure is approximately 2 fold over the first six years of life (e.g., at 1 year of age: 4.5 m³/d inhalation rate for 7.4 kg body weight for an inhalation rate/body weight ratio that is 2.1 fold larger than the adult assumption). Thus, the systemic and local respiratory tract dose to young children can be assumed to be approximately 2 fold larger than in adults for a significant portion of childhood. Since young children may be more generally sensitive to toxicants (many systems are immature and rapidly developing - Faustman, 2000), the potential importance of this exposure differential is accentuated. Thus, to be protective of children as potentially the most highly exposed and sensitive group, the residential TACs are adjusted by a 2 fold factor that corresponds with the greater inhalation exposure rate in children.

Children's increased vulnerability to toxicants has perhaps been best characterized in the area of carcinogenic risk. Standard cancer bioassays from which most unit risk values are derived, begin chemical administration when rodents are 4-6 weeks of age. At this age the animals are sexually mature and growth is not as rapid as in juvenile animals. Thus, this type of cancer study misses a potentially important vulnerability window. In fact, numerous cancer studies in which rodents were dosed beginning in early life demonstrate considerably greater potency in the neonatal period than at older ages (Vesselinovitch, et al., 1979; Toth, 1968; Maltoni, et al., 1981).

The reason for this greater susceptibility likely stems from the greater time period for expression of cancer when testing begins earlier in life, and because rapidly dividing tissues are more sensitive to genotoxicants (Laib, et al., 1985; Anderson, 2000). These issues have recently been summarized in a publication by CTDPH (Ginsberg, 2003) and by USEPA in their draft revisions to the cancer risk assessment guidelines (USEPA, 2003). The case of vinyl chloride sensitivity in early life stages has been evaluated closely by USEPA to support their recent revision to the vinyl chloride IRIS file (USEPA, 2000). That assessment showed that brief exposures in early life produced a cancer response later in life that was roughly equivalent to what would be seen from an adult-only (lifetime) exposure. On that basis, the IRIS file recommends that the unit risk factor for vinyl chloride derived for adults be doubled if there will be long-term exposure that will include children. Analysis of other juvenile animal bioassays indicates that this also appears to be true for a wide variety of chemicals, particularly those with a genotoxic mode of action (Ginsberg, 2003; USEPA, 2003). For this reason, the revised TACs for genotoxic carcinogens have an adjustment factor (2 fold lowering of TAC) to account for the greater sensitivity of early life stages (Ginsberg, 2003; USEPA, 2003).

In summary, the residential scenario includes a 2 fold adjustment factor for children's increased inhalation exposure rate relative to adults, and a 2 fold adjustment factor for children's increased sensitivity when exposed to genotoxic carcinogens. In this latter case, the combined children's adjustment factor is 4 fold. This approach is consistent with USEPA's IRIS file for vinyl chloride and draft Cancer Risk Assessment Guidelines. The Table B1 shows the use of these factors in deriving TACs.

Industrial/Commercial TAC Calculations

The industrial/commercial scenario is simpler than the residential scenario in that it only involves adults. The exposure parameters shown above for this scenario indicate that relative to the assumptions that go into RfCs and cancer unit risk values, workers will be exposed to less inhaled contaminant due to fewer hours/day of exposure (8 instead of 24 hr), fewer days per year of exposure (250 instead of 365), and fewer total years of exposure (25 instead of 70). The shorter hours per day of worker exposure is partially compensated for by the higher breathing rate workers may have compared to the general public. This leads to the assumption that 50% of the day's inhalation volume occurs while at work. In setting TACs for the workplace it is appropriate to increase the RfC by a factor of 2 for inhalation rate ($20\text{m}^3/\text{d}$ vs. $10\text{m}^3/\text{d}$) and by a factor of 1.46 for exposure days per year (365 vs. 250). This yields a combined workplace adjustment factor for RfCs of 2.92 (i.e., the workplace TAC can be 2.92 fold higher than the RfC). For carcinogens, the cumulative number of years is also part of the exposure calculation and so the 70/25 yr factor (2.8) is multiplied by 2.92 to yield a combined 8.176 adjustment factor. This factor is multiplied by the air concentration associated with de minimis risk for the general public to yield the air concentration corresponding to de minimis risk for workers. These exposure factors are in the Table B2 to show their use in deriving TACs for this scenario.

Ceiling TAC

The Tables B1 and B2 list a number of VOCs whose risk-based TAC is relatively high, a value that would allow gross contamination of indoor air. In these cases a ceiling value of $500\text{ug}/\text{m}^3$ is used. The ceiling value is based upon datasets showing that individual VOC concentrations in buildings tend to average less than $500\text{ug}/\text{m}^3$ across a broad array of building types and indoor air contaminants (Brown, et al., Indoor Air 4: 123-134, 1994). The 98th percentile value for these indoor air contaminants was highly variable but most values were between 50 and $1000\text{ug}/\text{m}^3$, indicating that a level of $500\text{ug}/\text{m}^3$ represents an upper bound concentration that stems from an unusual contamination source. Such high concentrations may contribute to decreases in air quality that are noticeable to building inhabitants (Otto, et al., 1990). Therefore, this ceiling value is a prudent default value that can be replaced when more specific information becomes available (e.g., odor threshold data), as indicated for several VOCs in this derivation.

Indoor Air Background Concentrations

Since 1996, there has been an increased focus around the United States on measuring indoor air quality in impacted and non-impacted (or "background") homes, offices, schools and other environments. This had led to an enhanced database for background indoor air data (Foster, et al., 2002; Kurtz and Folkes, 2002; NYSDOH, 1997; Clayton, et al., 1999; Shields, et al., 1996; Girman, et al. report of USEPA/BASE Study, 1999). These datasets, along with the pre-existing indoor air datasets (Stolwick, 1990; Vermont DOH, 1992; Brown, et al., 1994; Daisey, et al., 1994; Sheldon, et al., 1992; Shah and Singh, 1988) have been reviewed while giving particular attention to those VOCs (typically carcinogens) with risk-based TACs that are in the range where they may approach or are below what can be considered background. VOC indoor air measurements are typically lognormally distributed; therefore, the central tendency background concentration (the median) was chosen to represent background. While higher concentrations may be found in certain background locations, the central tendency was used because of the way it would be applied: 1) to replace a risk-based TAC such that the background concentration would already be above a risk target; and 2) to back-calculate the allowable contribution from subsurface VOC contamination, such that the amount that is from

background sources plus the amount allowed from subsurface sources would still be within the range of the background data distribution.

VOC background concentrations and how they are used in the derivation of TACs are shown chemical-by-chemical in Tables B1 and B2.

Table B1

Target Air Concentrations (TACs) for Residential Scenario (Page 1)

VOC	Toxicity Value¹	Modifying Factors²	Risk-Based TAC⁴	Background	TAC
Acetone	IRIS RfD (0.1mg/kg-d) converted to RfC (350 ug/m ³)	2x CexpF	183 ug/m ³	--- ⁷	180 ug/m ³
Benzene	IRIS unit risk (8.3E-6/ug/m ³)	2x CexpF; 2x CsensF	0.07 ug/m ³	3.25 ug/m ³	3.3 ug/m ³
Bromoform	IRIS unit risk (1.1E-6/ug/m ³)	2x CexpF; 2x CsensF	2.2 ug/m ³	Not available	0.55 ug/m ³
2-Butanone (MEK)	IRIS RfC (1000 ug/m ³)	2x CexpF	520 ug/m ³	--- ⁷	500 ug/m ³ – C ³
Carbon Tetrachloride	IRIS unit risk (1.5E-5/ug/m ³)	2x CexpF; 2x CsensF	0.04 ug/m ³	0.5 ug/m ³	0.5 ug/m ³
Chlorobenzene	IRIS RfD (0.02 mg/kg-d) converted to RfC (70 ug/m ³)	2x CexpF	37 ug/m ³	--- ⁷	37 ug/m ³
Chloroform	IRIS unit risk (2.3E-5/ug/m ³)	2x CexpF	0.05 ug/m ³	0.5 ug/m ³	0.5 ug/m ³
1,2-Dichlorobenzene	HEAST RfC (140 ug/m ³)	2x CexpF	73 ug/m ³	--- ⁷	73 ug/m ³
1,3-Dichlorobenzene	Analogy with 1,2-DCB	2x CexpF	73 ug/m ³	--- ⁷	73 ug/m ³
1,4-Dichlorobenzene	EPA Provisional unit risk (6.3E-06/ug/m ³)	None – since provisional unit risk	0.39 ug/m ³	24 ug/m ³	24 ug/m ³
1,1-Dichloroethane	HEAST (“A”) RfC (490ug/m ³)	3.33x Cancer UF; 2x CexpF	77 ug/m ³	--- ⁷	77 ug/m ³
1,2-Dichloroethane	IRIS unit risk (2.6E-5/ug/m ³)	2x CexpF; 2x CsensF	0.023 ug/m ³	0.07 ug/m ³	0.07 ug/m ³
1,1-Dichloroethylene	CalEPA REL (70 ug/m ³); ATSDR MRL (80 ug/m ³)	10x Cancer UF	7 ug/m ³	<5 ug/m ³	10 ug/m ³
1,2-Dichloropropane	EPA provisional oral slope → unit risk (1.9E-05/ug/m ³)	None – since provisional unit risk	0.13 ug/m ³	Not available	0.13 ug/m ³
1,3-Dichloropropene	IRIS unit risk (2.9E-6/ug/m ³)	2x CexpF; 2x CsensF	0.21 ug/m ³	Not available	0.21 ug/m ³
Ethylbenzene	IRIS RfC (1000 ug/m ³)	10x Cancer UF; 2x CexpF	53 ug/m ³	<10 ug/m ³	53 ug/m ³
Ethylene dibromide	IRIS unit risk (2.2E-04)	2x CexpF; 2x CsensF	0.003 ug/m ³	Not available	0.0028 ug/m ³

Table B1**Target Air Concentrations (TACs) for Residential Scenario** (Page 2)

VOC	Toxicity Value¹	Modifying Factors²	Risk-Based TAC⁴	Background	TAC
Methyl-t-butyl ether	IRIS RfC (3000 ug/m ³)	10x Cancer UF; 2x CexpF	160 ug/m ³	--- ⁷	160 ug/m ³
Methyl isobutyl ketone	HEAST(A") RfC (70 ug/m ³)	2x CexpF	37 ug/m ³	--- ⁷	37 ug/m ³
Methylene chloride	IRIS unit risk (4.7E-07/ug/m ³)	2x CexpF	2.6 ug/m ³	3 ug/m ³	3 ug/m ³
Styrene	IRIS RfC (1000 ug/m ³)	10x Cancer UF; 2x CexpF	52 ug/m ³	--- ⁷	52 ug/m ³
1,1,1,2-Tetrachloroethane	IRIS unit risk (7.43E-06/ug/m ³)	2x CexpF; 2x CsensF	0.082 ug/m ³	Not available	0.082 ug/m ³
1,1,2,2-Tetrachloroethane	IRIS unit risk (5.7E-05/ug-m ³)	2x CexpF; 2x CsensF	0.01 ug/m ³	Not available	0.01 ug/m ³
Tetrachloroethylene (PERC)	CalEPA unit risk (5.9E-06/ug/m ³)	2x CexpF	0.21 ug/m ³	5 ug/m ³	5 ug/m ³
Toluene	IRIS RfC (400 ug/m ³)	2x CexpF	208 ug/m ³	--- ⁷	210 ug/m ³
1,1,1-Trichloroethane	CalEPA REL (1000 ug/m ³)	2x CexpF	520 ug/m ³	--- ⁷	500 ug/m ³ - C ³
1,1,2-Trichloroethane	IRIS RfD converted to RfC (14 ug/m ³)	3.33x Cancer UF; 2x CexpF	2.2 ug/m ³	0.03 ug/m ³	2.2 ug/m ³
Trichloroethylene	IRIS provisional unit risk (1.1E-04/ug/m ³)	2x CexpF; 2x CsensF	0.006 ug/m ³	1 ug/m ³	1 ug/m ³
Vinyl chloride	IRIS unit risk for early life + adult exposure (8.6E-06/ug/m ³)	2x CexpF	0.14 ug/m ³	0.01 ug/m ³	0.14 ug/m ³
Xylenes	ATSDR MRL (430 ug/m ³)	2x CexpF	220 ug/m ³	--- ⁷	220 ug/m ³
Trichlorofluoromethane	HEAST ("A")RfC (700 ug/m ³)	2x CexpF	365 ug/m ³	--- ⁷	370 ug/m ³

Table B1

Target Air Concentrations (TACs) for Residential Scenario (Page 3)

VOC	Toxicity Value¹	Modifying Factors²	Risk-Based TAC⁴	Background	TAC
Chloroethane	IRIS RfC (10,000 ug/m ³)	10x Cancer UF; 2x CexpF	520 ug/m ³	--- ⁷	500 ug/m ³ - C ³
Chloromethane	IRIS RfC (90 ug/m ³)	3.33x Cancer UF; 2x CexpF	14 ug/m ³	Not available	14 ug/m ³
Dichlorodifluoromethane	HEAST ("A")RfC (175 ug/m ³)	2x CexpF	91 ug/m ³	--- ⁷	91 ug/m ³
Isopropylbenzene (cumene)	IRIS RfC (385 ug/m ³)	2x CexpF	200 ug/m ³	--- ⁷	120 ug/m ³ (odor threshold)
cis-1,2-Dichloroethene	HEAST RfD → RfC (35 ug/m ³)	2x CexpF	18 ug/m ³	Not available	18 ug/m ³
trans-1,2-Dichloroethane	IRIS RfD → RfC (70 ug/m ³)	2x CexpF	37 ug/m ³	--- ⁷	37 ug/m ³
Bromodichloromethane	IRIS oral slope factor → unit risk (1.8E-05/ug/m ³)	2x CexpF; 2x CsensF	0.034 ug/m ³	Not available	0.034 ug/m ³
n-Butylbenzene	EPA provisional RfD → RfC (140 ug/m ³)	2x CexpF	73 ug/m ³	--- ⁷	73 ug/m ³
sec-Butylbenzene	EPA provisional RfD → RfC (140 ug/m ³)	2x CexpF	73 ug/m ³	--- ⁷	73 ug/m ³
1,2,4-Trimethylbenzene	EPA Provisional RfC (6 ug/m ³)	RfC ↑ed 3x ⁵ 2x CexpF	9 ug/m ³	Not available	9.3 ug/m ³
1,3,5Trimethylbenzene	EPA Provisional RfC (6 ug/m ³)	RfC ↑ed 3x ⁵ 2x CexpF	9 ug/m ³	Not available	9.3 ug/m ³
4-Isopropyltoluene	DPH risk assessment ⁶ yields RfC of 133 ug/m ³	2x CexpF	67 ug/m ³	--- ⁷	67 ug/m ³

Footnotes for Residential TAC Table B1

¹ Tox Value Notes: Values from IRIS, HEAST, CalEPA chronic RELs or ATSDR chronic MRLs; EPA provisional values have been derived by the agency but not fully documented or supported; HEAST "A" refers to values from Alternative Table within HEAST. Dose route extrapolation conducted when no inhalation tox value available and oral toxicity is to systemic sites.

² Modifying Factors: CexpF = children's exposure factor for increased respiratory rate per body wt and respiratory surface area;
CsensF = children's sensitivity factor for genotoxic carcinogens
Cancer UF = uncertainty factor for evidence of carcinogenicity but extrapolation to low dose uncertain.

³ "C" designation indicates ceiling value of 500 ug/m³.

⁴ TACs based upon de minimis (1 in a million) cancer risk or a hazard index of 1 for non-cancer effects.

⁵ EPA provisional RfC for 1,2,4- and 1,3,5-TMB have unnecessarily large uncertainty factors which drive very low RfC.

⁶ 4-Isopropyltoluene risk assessment based upon analogy with isopropylbenzene with evidence neurotoxicity as key endpoint (4-IPT 3x > potency than IPB).

⁷ Background concentration not sought since risk-based TAC is relatively high and unlikely to be in range of background.

Table B2

Target Air Concentrations (TACs) for Industrial/Commercial Scenario (Page 1)

VOC	Toxicity Value¹	Modifying Factors²	Risk-Based TAC⁴	Background	TAC
Acetone	IRIS RfD (0.1mg/kg-d) converted to RfC (350 ug/m ³)	2.92 less worker exp.	1022 ug/m ³	--- ⁷	500 ug/m ³ – C ³
Benzene	IRIS unit risk (8.3E-6/ug/m ³)	8.176 less worker exp.	0.99 ug/m ³	3.25 ug/m ³	3.3 ug/m ³
Bromoform	IRIS unit risk (1.1E-6/ug/m ³)	8.176 less worker exp.	7.34 ug/m ³	Not available	7.3 ug/m ³
2-Butanone (MEK)	IRIS RfC (1000 ug/m ³)	2.92 less worker exp.	2900 ug/m ³	--- ⁷	500 ug/m ³ – C ³
Carbon Tetrachloride	IRIS unit risk (1.5E-5/ug/m ³)	8.176 less worker exp.	0.54 ug/m ³	0.5 ug/m ³	0.54 ug/m ³
Chlorobenzene	IRIS RfD (0.02 mg/kg-d) converted to RfC (70 ug/m ³)	2.92 less worker exp.	200 ug/m ³	--- ⁷	200 ug/m ³
Chloroform	IRIS unit risk (2.3E-5/ug/m ³)	8.176 less worker exp.	0.36 ug/m ³	0.5 ug/m ³	0.5 ug/m ³
1,2-Dichlorobenzene	HEAST RfC (140 ug/m ³)	2.92 less worker exp.	410 ug/m ³	--- ⁷	410 ug/m ³
1,3-Dichlorobenzene	Analogy with 1,2-DCB	2.92 less worker exp.	410 ug/m ³	--- ⁷	410 ug/m ³
1,4-Dichlorobenzene	EPA Provisional unit risk (6.3E-06/ug/m ³)	8.176 less worker exp.	1.3 ug/m ³	24 ug/m ³	24 ug/m ³
1,1-Dichloroethane	HEAST ("A") RfC (490 ug/m ³)	3.33x Cancer UF; 2.92 less worker exp.	430 ug/m ³	--- ⁷	430 ug/m ³
1,2-Dichloroethane	IRIS unit risk (2.6E-5/ug/m ³)	8.176 less worker exp.	0.31 ug/m ³	0.07 ug/m ³	0.31 ug/m ³
1,1-Dichloroethylene	CalEPA REL (70 ug/m ³); ATSDR MRL (80 ug/m ³)	10x Cancer UF	20 ug/m ³	<5 ug/m ³	20 ug/m ³
1,2-Dichloropropane	EPA provisional oral slope → unit risk (1.9E-05/ug/m ³)	8.176 less worker exp.	0.42 ug/m ³	Not available	0.42 ug/m ³
1,3-Dichloropropene	IRIS unit risk (2.9E-6/ug/m ³)	8.176 less worker exp.	2.9 ug/m ³	Not available	2.9 ug/m ³
Ethylbenzene	IRIS RfC (1000 ug/m ³)	10x Cancer UF; 2.92 less worker exp.	290 ug/m ³	<10 ug/m ³	290 ug/m ³
Ethylene dibromide	IRIS unit risk (2.2E-04)	8.176 less worker exp.	0.038 ug/m ³	Not available	0.038 ug/m ³

Table B2**Target Air Concentrations (TACs) for Industrial/Commercial Scenario (Page 2)**

VOC	Toxicity Value¹	Modifying Factors²	Risk-Based TAC⁴	Background	TAC
Methyl-t-butyl ether	IRIS RfC (3000 ug/m ³)	10x Cancer UF; 2.92 less worker exp.	876 ug/m ³	--- ⁷	190 ug/m ³ (odor threshold)
Methyl isobutyl ketone	HEAST(A") RfC (70 ug/m ³)	2.92 less worker exp.	200 ug/m ³	--- ⁷	200 ug/m ³
Methylene chloride	IRIS unit risk (4.7E-07/ug/m ³)	8.176 less worker exp.	17 ug/m ³	3 ug/m ³	17 ug/m ³
Styrene	IRIS RfC (1000 ug/m ³)	10x Cancer UF; 2.92 less worker exp.	290 ug/m ³	--- ⁷	290 ug/m ³
1,1,1,2-Tetrachloroethane	IRIS unit risk (7.43E-06/ug-3)	8.176 less worker exp.	1.1 ug/m ³	Not available	1.1 ug/m ³
1,1,2,2-Tetrachloroethane	IRIS unit risk (5.7E-05/ug-m3)	8.176 less worker exp.	0.14 ug/m ³	Not available	0.14 ug/m ³
Tetrachloroethylene (PERC)	CalEPA unit risk (5.9E-06/ug/m ³)	8.176 less worker exp.	1.4 ug/m ³	5 ug/m ³	5 ug/m ³
Toluene	IRIS RfC (400 ug/m ³)	2.92 less worker exp.	1165 ug/m ³	--- ⁷	500 ug/m ³ - C ³
1,1,1-Trichloroethane	CalEPA REL (1000 ug/m ³)	2.92 less worker exp.	2900 ug/m ³	--- ⁷	500 ug/m ³ - C ³
1,1,2-Trichloroethane	IRIS RfD converted to RfC (14 ug/m ³)	3.33x Cancer UF; 2.92 less worker exp.	12.3 ug/m ³	0.03 ug/m ³	12 ug/m ³
Trichloroethylene	IRIS provisional unit risk (1.1E-04/ug/m ³)	8.176 less worker exp.	0.074 ug/m ³	1 ug/m ³	1 ug/m ³
Vinyl chloride	IRIS unit risk for adult exposure (4.3E-6/ug/m ³)	8.176 less worker exp.	1.9 ug/m ³	0.01 ug/m ³	1.9 ug/m ³
Xylenes	ATSDR MRL (430 ug/m ³)	2.92 less worker exp.	1256 ug/m ³	--- ⁷	500 ug/m ³ - C ³
Trichlorofluoromethane	HEAST ("A")RfC (700 ug/m ³)	2.92 less worker exp.	2044 ug/m ³	--- ⁷	500 ug/m ³ - C ³

Table B2**Target Air Concentrations (TACs) for Industrial/Commercial Scenario** (Page 3)

VOC	Toxicity Value¹	Modifying Factors²	Risk-Based TAC⁴	Background	TAC
Chloroethane	IRIS RfC (10,000 ug/m ³)	10x Cancer UF; 2.92 less worker exp.	2920 ug/m ³	--- ⁷	500 ug/m ³ - C ³
Chloromethane	IRIS RfC (90 ug/m ³)	3.33x Cancer UF; 2.92 less worker exp.	80 ug/m ³	Not available	80 ug/m ³
Dichlorodifluoromethane	HEAST ("A")RfC (175 ug/m ³)	2.92 less worker exp.	511 ug/m ³	--- ⁷	500 ug/m ³ - C ³
Isopropylbenzene (cumene)	IRIS RfC (385 ug/m ³)	2.92 less worker exp.	1168 ug/m ³	--- ⁷	120 ug/m ³ (odor threshold)
cis-1,2-Dichloroethene	HEAST RfD → RfC (35 ug/m ³)	2.92 less worker exp.	102 ug/m ³	Not available	100 ug/m ³
trans-1,2-Dichloroethane	IRIS RfD → RfC (70 ug/m ³)	2.92 less worker exp.	204 ug/m ³	--- ⁷	200 ug/m ³
Bromodichloromethane	IRIS oral slope factor → unit risk (1.8E-05/ug/m ³)	8.176 fold less exp.	0.46 ug/m ³	Not available	0.46 ug/m ³
n-Butylbenzene	EPA provisional RfD → RfC (140 ug/m ³)	2.92 less worker exp.	410 ug/m ³	--- ⁷	410 ug/m ³
sec-Butylbenzene	EPA provisional RfD → RfC (140 ug/m ³)	2.92 less worker exp.	410 ug/m ³	--- ⁷	410 ug/m ³
1,2,4-Trimethylbenzene	EPA Provisional RfC (6 ug/m ³)	RfC ↑ed 3x ⁵ 2.92 less worker exp.	52 ug/m ³	Not available	52 ug/m ³
1,3,5-Trimethylbenzene	EPA Provisional RfC (6 ug/m ³)	RfC ↑ed 3x ⁵ 2.92 less worker exp.	52 ug/m ³	Not available	52 ug/m ³
4-Isopropyltoluene	DPH risk assessment ⁶ yields RfC of 133 ug/m ³	2.92 less worker exp.	370 ug/m ³	--- ⁷	370 ug/m ³

Footnotes for Industrial/Commercial TAC Table

¹ Tox Value Notes: Values from IRIS, HEAST, CalEPA chronic RELs or ATSDR chronic MRLs; EPA provisional values have been derived by the agency but not fully documented or supported; HEAST "A" refers to values from Alternative Table within HEAST. Dose route extrapolation conducted when no inhalation tox value available and oral toxicity is to systemic sites.

² Modifying Factors: Worker exposure assumptions for non-cancer effects: 250d/year and 10m³ inhaled per day leads to 2.92 fold less cumulative exposure than assumed for RfC – general public. For carcinogenic effects, this factor is increased 2.8 fold because workers exposed 25 yr instead of 70 yr leading to an overall 8.176 fold lower cumulative exposure than general public.

³ "C" designation indicates ceiling value of 500 ug/m³.

⁴ TACs based upon de minimis (1 in a million) cancer risk or a hazard index of 1 for non-cancer effects.

⁵ EPA provisional RfCs for 1,2,4- and 1,3,5-TMB have unnecessarily large uncertainty factors which drive very low RfC.

⁶ 4-Isopropyltoluene risk assessment based upon analogy with isopropylbenzene with neurotoxicity as key endpoint (4-IPT 3x > potency than IPB).

⁷ Background concentration not sought since risk-based TAC is relatively high and unlikely to be in range of background.

Appendix C

Comparison to 1996 Volatilization Criteria

Table C1

Comparison of Target Indoor Air Concentrations

Compound	CAS Number	Residential TAC (ug/m³)	1995 Residential TAC (ug/m³)	Ind/Com TAC (ug/m³)	1995 Ind/Com TAC (ug/m³)
Acetone	67641	▼180	834	▼500 ⁽¹⁾	1170
Acrylonitrile	107131	NA	NA	NA	NA
Benzene	71432	►3.3 ⁽²⁾	3.25 ⁽²⁾	▼3.3 ⁽²⁾	21.5 ⁽²⁾
Bromoform	75252	▼0.55	2.21	▲7.3	3.72
2-Butanone (MEK)	78933	▼500 ⁽¹⁾	1040	▼500 ⁽¹⁾	1460
Carbon tetrachloride	56235	▼0.5 ⁽²⁾	1 ⁽²⁾	▼0.54	1 ⁽²⁾
Chlorobenzene	108907	▲37	20.9	▲200	29.2
Chloroform	67663	▼0.5 ⁽²⁾	3 ⁽²⁾	▼0.5 ⁽²⁾	3 ⁽²⁾
Dibromochloromethane	124481	NA	NA	NA	NA
1,2-Dichlorobenzene	95501	▼73	209	▲410	292
1,3-Dichlorobenzene	541731	▼73	209	▲410	292
1,4-Dichlorobenzene	106467	▼24 ⁽²⁾	834	▼24 ⁽²⁾	1170
1,1-Dichloroethane	75343	▼77	521	▼430	730
1,2-Dichloroethane	107062	▼0.07	0.0936	▲0.31	0.157
1,1-Dichloroethylene	75354	▲10	0.0487	▲20	0.0818
cis-1,2-Dichloroethylene	156592	See New Criteria below	NA	See New Criteria below	NA
trans-1,2-Dichloroethylene	156605	See New Criteria below	NA	See New Criteria below	NA
1,2-Dichloropropane	78875	►0.13	0.128	▲0.42	0.215
1,3-Dichloropropene	542756	▲0.21	0.0658	▲2.9	0.11
Ethyl benzene	100414	▼53	1040	▼290	1460
Ethylene dibromide (EDB)	106934	▼0.0028	0.0111	▲0.038	0.0186
Methyl-tert-butyl-ether	1634044	▼160	521	▼190 ⁽³⁾	730
Methyl isobutyl ketone	108101	▼37	83.4	▲200	117
Methylene chloride	75092	▼3 ⁽²⁾	45 ⁽²⁾	▼17	45 ⁽²⁾
Styrene	100425	▲52	5 ⁽²⁾	▲290	7.17

Table C1
(Continued)

Comparison of Target Indoor Air Concentrations

Compound	CAS Number	Residential TAC (ug/m ³)	1996 Residential TAC (ug/m ³)	Ind/Com TAC (ug/m ³)	1996 Ind/Com TAC (ug/m ³)
1,1,1,2-Tetrachloroethane	630206	▼ 0.082	0.329	▲ 1.1	0.552
1,1,2,2-Tetrachloroethane	79345	▼ 0.011	0.042	▲ 0.14	0.0705
Tetrachloroethylene	127184	▼ 5 ⁽²⁾	11 ⁽²⁾	▼ 5 ⁽²⁾	11 ⁽²⁾
Toluene	108883	▼ 210	417	▼ 500 ⁽¹⁾	584
1,1,1 Trichloroethane	71556	▼ 500	1040	▼ 500 ⁽¹⁾	1460
1,1,2-Trichloroethane	79005	▼ 2.2	30 ⁽²⁾	▼ 12	30 ⁽²⁾
Trichloroethylene	79016	▼ 1 ⁽²⁾	5 ⁽²⁾	▼ 1 ⁽²⁾	5 ⁽²⁾
Vinyl chloride	75014	▲ 0.14	0.029	▲ 1.9	0.0487
Xylenes	1330207	▼ 220	313	▲ 500 ⁽¹⁾	438
New Criteria					
Trichlorofluoromethane	75694	370	NA	500 ⁽¹⁾	NA
Chloroethane	75003	500 ⁽¹⁾	NA	500 ⁽¹⁾	NA
Chloromethane	74873	14	NA	80	NA
Dichlorodifluoromethane	75718	91	NA	500 ⁽¹⁾	NA
Isopropylbenzene (Cumene)	98828	120 ⁽³⁾	NA	120 ⁽³⁾	NA
cis-1,2-dichloroethene	156592	18	NA	100	NA
trans-1,2-dichloroethene	156605	37	NA	200	NA
Bromodichloromethane	75274	0.034	NA	0.46	NA
N-butylbenzene	104518	73	NA	410	NA
Sec-butylbenzene	135988	73	NA	410	NA
1,2,4-trimethylbenzene	95636	9.3	NA	52	NA
1,3,5-trimethylbenzene	108678	9.3	NA	52	NA
4-isopropyltoluene (4-cymene)	99876	67	NA	370	NA

⁽¹⁾ Based on a ceiling value. ⁽²⁾ Based on a background concentration. ⁽³⁾ Based on an odor threshold concentration. ▲ TAC increased. ▼ TAC decreased. ► TAC stayed the same.

Table C2

Comparison of Ground Water Volatilization Criteria

Compound	CAS Number	Residential GWVC (ug/L)	1996 Residential GWVC (ug/L)	Ind/Com GWVC (ug/L)	1996 Ind/Com GWVC (ug/L)
Acetone	67641	▶ 50000	50000	▶ 50000	50000
Acrylonitrile	107131	NA	NA	NA	NA
Benzene	71432	▼ 130	215	▼ 310	3491
Bromoform	75252	▼ 75	920	▼ 2300	3800
2-Butanone (MEK)	78933	▶ 50000	50000	▶ 50000	50000
Carbon tetrachloride	56235	▼ 5.3	16	▼ 14	40
Chlorobenzene	108907	▶ 1800	1800	▲ 23000	6150
Chloroform	67663	▼ 26	287	▼ 62	710
Dibromochloromethane	124481	NA	NA	NA	NA
1,2-Dichlorobenzene	95501	▼ 5100	30500	▶ 50000	50000
1,3-Dichlorobenzene	541731	▼ 4300	24200	▶ 50000	50000
1,4-Dichlorobenzene	106467	▼ 1400	50000	▼ 3400	50000
1,1-Dichloroethane	75343	▼ 3000	34600	▼ 41000	50000
1,2-Dichloroethane	107062	▼ 6.5	21	▼ 68	90
1,1-Dichloroethylene	75354	▲ 190	1	▲ 920	6
cis-1,2-Dichloroethylene	156592	See New Criteria below	NA	See New Criteria below	NA
trans-1,2-Dichloroethylene	156605	See New Criteria below	NA	See New Criteria below	NA
1,2-Dichloropropane	78875	▼ 7.4	14	▶ 58	60
1,3-Dichloropropene	542756	▲ 11	6	▲ 360	25
Ethyl benzene	100414	▼ 2700	50000	▼ 36000	50000
Ethylene dibromide (EDB)	106934	▼ 0.3	4	▼ 11	16
Methyl-tert-butyl-ether	1634044	▼ 21000	50000	▶ 50000	50000
Methyl isobutyl ketone	108101	▼ 13000	50000	▶ 50000	50000
Methylene chloride	75092	▼ 160	4512	▼ 2200	11117
Styrene	100425	▲ 3100	580	▲ 42000	2065

Table C2
(Continued)

Comparison of Ground Water Volatilization Criteria

Compound	CAS Number	Residential GWVC (ug/L)	1996 Residential GWVC (ug/L)	Ind/Com GWVC (ug/L)	1996 Ind/Com GWVC (ug/L)
1,1,1,2-Tetrachloroethane	630206	▼2	12	▲64	50
1,1,2,2-Tetrachloroethane	79345	▼1.8	23	▼54	100
Tetrachloroethylene	127184	▼340	1500	▼810	3820
Toluene	108883	▼7100	23500	▼41000	50000
1,1,1-Trichloroethane	71556	▼6500	20400	▼16000	50000
1,1,2-Trichloroethane	79005	▼220	8000	▼2900	19600
Trichloroethylene	79016	▼27	219	▼67	540
Vinyl chloride	75014	►1.6	2	▲52	2
Xylenes	1330207	▼8700	21300	▼48000	50000
New Criteria					
Trichlorofluoromethane	75694	1300	NA	4200	NA
Chloroethane	75003	12000	NA	29000	NA
Chloromethane	74873	390	NA	5500	NA
Dichlorodifluoromethane	75718	93	NA	1200	NA
Isopropylbenzene (Cumene)	98828	2800	NA	6800	NA
Cis-1,2-dichloroethene	156592	830	NA	11000	NA
trans-1,2-dichloroethene	156605	1000	NA	13000	NA
Bromodichloromethane	75274	2.3	NA	73	NA
N-butylbenzene	104518	1500	NA	21000	NA
Sec-butylbenzene	135988	1500	NA	20000	NA
1,2,4-trimethylbenzene	95636	360	NA	4800	NA
1,3,5-trimethylbenzene	108678	280	NA	3900	NA
4-isopropyltoluene (4-cymene)	99876	1600	NA	22000	NA
▲ GWVC increased. ▼ GWVC decreased. ► GWVC stayed the same.					

Table C3

Comparison of Soil Vapor Volatilization Criteria

Compound	CAS Number	Residential SVVC (ppm)	1996 Residential SVVC (ppm)	Ind/Com SVVC (ppm)	1996 Ind/Com SVVC (ppm)
Acetone	67641	▼57	2400	▼290	8250
Acrylonitrile	107131	NA	NA	NA	NA
Benzene	71432	▼0.78	1	▼1.4	113
Bromoform	75252	▼0.04	1.5	▼0.98	6
2-Butanone (MEK)	78933	▼130	2400	▼230	8285
Carbon tetrachloride	56235	▼0.06	1	▼0.12	2.7
Chlorobenzene	108907	▼6.1	31	▼60	106
Chloroform	67663	▼0.078	4.5	▼0.14	10.4
Dibromochloromethane	124481	NA	NA	NA	NA
1,2-Dichlorobenzene	95501	▼9.2	240	▼95	818
1,3-Dichlorobenzene	541731	▼9.2	240	▼95	818
1,4-Dichlorobenzene	106467	▼3	950	▼5.5	3270
1,1-Dichloroethane	75343	▼14	850	▼150	3037
1,2-Dichloroethane	107062	▼0.013	1	▼0.11	1
1,1-Dichloroethylene	75354	▲1.9	1	▲7	1
cis-1,2-Dichloroethylene	156592	See New Criteria below	NA	See New Criteria below	NA
trans-1,2-Dichloroethylene	156605	See New Criteria below	NA	See New Criteria below	NA
1,2-Dichloropropane	78875	▼0.021	1	▼0.13	1
1,3-Dichloropropene	542756	▼0.035	1	▼0.89	1
Ethyl benzene	100414	▼9.3	1650	▼93	5672
Ethylene dibromide (EDB)	106934	▼0.0005	1	▼0.007	1
Methyl-tert-butyl-ether	1634044	▼34	1000	▼73	3415
Methyl isobutyl ketone	108101	▼6.8	140	▼68	480
Methylene chloride	75092	▼0.65	89	▼6.8	218
Styrene	100425	▲9.3	8	▲95	28

Table C3
(Continued)

Comparison of Soil Vapor Volatilization Criteria

Compound	CAS Number	Residential SVVC (ppm)	1996 Residential SVVC (ppm)	Ind/Com SVVC (ppm)	1996 Ind/Com SVVC (ppm)
1,1,1,2-Tetrachloroethane	630206	▼0.009	1	▼0.22	1.5
1,1,2,2-Tetrachloroethane	79345	▼0.0012	1	▼0.028	1
Tetrachloroethylene	127184	▼0.56	11	▼1	27
Toluene	108883	▼42	760	▼180	2615
1,1,1 Trichloroethane	71556	▼70	1310	▼130	4520
1,1,2-Trichloroethane	79005	▼0.31	40	▼3.1	93
Trichloroethylene	79016	▼0.14	7	▼0.26	16
Vinyl chloride	75014	▼0.041	1	►1	1
Xylenes	1330207	▼38	500	▼160	1702
New Criteria					
Trichlorofluoromethane	75694	50	NA	120	NA
Chloroethane	75003	140	NA	260	NA
Chloromethane	74873	5.1	NA	53	NA
Dichlorodifluoromethane	75718	14	NA	140	NA
Isopropylbenzene (Cumene)	98828	19	NA	34	NA
Cis-1,2-dichloroethene	156592	3.4	NA	35	NA
trans-1,2-dichloroethene	156605	7.1	NA	70	NA
Bromodichloromethane	75274	0.0038	NA	0.095	NA
N-butylbenzene	104518	10	NA	100	NA
Sec-butylbenzene	135988	10	NA	100	NA
1,2,4-trimethylbenzene	95636	1.4	NA	15	NA
1,3,5-trimethylbenzene	108678	1.4	NA	15	NA
4-isopropyltoluene (4-cymene)	99876	9.3	NA	94	NA
▲ SVVC increased. ▼ SVVC decreased. ► SVVC stayed the same.					